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# HISTORY

OF THE



PROGRESS

AND

PRESENT STATE

OF

## ANIMAL CHEMISTRY.

BY

W. B. JOHNSON, M.B.

IN THREE VOLUMES.

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Page 13, line 12 from bot. *for* nitrous acid *read* nitric acid—P. 41, l. 10, *for* Humbolds *r.* Humboldt—P. 46, l. 15, *for* animal acid *r.* animal acids—P. 48, l. 6, *for* to being *r.* to be—P. 74, l. 25, *for* magnesia *r.* manganese—P. 81, l. 3, *for* nitres *r.* nitrats—P. 96, l. 15 from bot. *for* phosphorus *r.* phosphorous—P. 96, l. 13 from bot. *for* phosphorous *r.* phosphorus—P. 106, last line. *for* how *r.* how they—P. 127, l. 18, *for* them *r.* it—P. 128, l. 25, *for* state *r.* state of—P. 136, l. 31, *for* selenite *r.* selenitic—P. 197, l. 18, *for* effervesces *r.* effloresces—P. 156, l. 11, *for* compared *r.* been compared—P. 163, l. 20, *for* phosphoroas *r.* phosphorous—ib. l. 29, *for* is *r.* it—P. 210, l. 1 and 7, *dele* “ ”—P. 237, l. 15, *for* Dr. Hume *r.* Dr. Hulme—P. 240, line 8 from bot. *for* Dr. Hume *r.* Dr. Hulme—P. 258, l. 11, *for* surround *r.* surrounds—P. 260, between line 6 and 7, *insert* l. Coccus cacti or cochineal—P. 290, l. 2, *for* on the *r.* of the—P. 302, l. 8, *for* appearance *r.* apparent effect—P. 331, l. 10 from bot. *for* insolubility *r.* solubility—P. 337, l. 23. *for* of costalis *r.* costalis—P. 343, l. 7, *dele* to—P. 355, l. 10 from bot. *for* dissolves *r.* dissolve—P. 361, l. 16, *for* when out of *r.* when in—P. 364, l. 8, *for* decoction *r.* concoction—P. 366, l. 17, *for* informs *r.* inform—P. 369, l. 8, *for* acid *r.* acids—P. 371, l. 30, *for* if first *r.* if fresh—P. 420, l. 29, *for* gas *r.* gases—P. 424, l. 17, *for* excrementitial *r.* excrementitious—P. 426, l. 27, *for* frequented *r.* unfrequented—P. 450, l. 24, *for* more less *r.* more or less—ib. l. 33, *for* of most *r.* in most—P. 454, l. 18, *for* quantity *r.* the quantity—P. 453, l. 7, *for* chalk *r.* salt—Page 84 is marked by mistake 34.

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THE  
HISTORY  
OF  
*ANIMAL CHEMISTRY.*

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OILS.

UNDER this article are to be included all those ani- Animal oils,  
mal substances that have an unctuous or greasy feel when  
rubbed between the fingers, are more or less easily made  
to inflame, and when united with certain bodies, as for  
instance, caustic alkalis, form soap; an acid may likewise  
be extracted from them. They are in general much less  
fluid than the fat oils of plants, and some of them in a  
concrete state, seem to have undergone a species of crys-  
tallization.

It appears, that almost all animal substances are capa-  
ble of being converted into a more or less concrete oil  
possessing the above properties, by depriving them of cer-  
tain of their component parts; this takes place in a na-  
tural way in cemeteries, where large heaps of animal bo-

dies are amassed together; or this effect may be produced artificially, as by means of the nitrous acid; or by placing animal substances in such a situation as to give the carbon and hydrogen an opportunity of forming an intimate union; hence in the distillation of animal substances the more or less quantity of fluid oil obtained is said to be owing to this union of its two component parts by the aid of heat.

**Varieties.**

The oil of animals differs very much in consistence; in the herbivorous and frugivorous tribes it is firm and solid, and is called *fuet*; it is less concrete in the carnivorous class, in birds and in the pig, in which it is called *grease* and *lard*, as bear's grease, goose grease, and hog's lard; it is still less so in milk, where it is called *butter*, and in the bone, called *marrow*, whilst in the palmata and cetacea classes, and in fish it is nearly fluid, and is called *blubber* and *oil*. It is likewise less solid and concrete in the living than in the dead animal, and it varies even according to the parts, thus it is more solid near the kidneys and beneath the skin, and less firm between the muscular fibres or near the moveable viscera, such as the heart, stomach, and intestines. This more or less concrete state which an animal oil is subject to, is said to be owing to the absorption of oxygen, it has likewise been said to arise more particularly in fat from the sebatic acid.

Abounds  
more or less  
in different  
animals and  
parts.

Animal oil is found to vary in quantity in different classes of animals. On comparing the quantity of it with the bulk of the body, it is more abundant in the cetaceous class than in amphibious quadrupeds, and more so in the last than in the frugivorous class. Carnivorous animals have the least quantity. Lastly, it is more abundant in winter than in summer, and appears destined to maintain the heat in those regions where it is placed, and to contribute to the nourishment of animals, as is observable in bears, the mountain rat, the dormouse, and in general in all

animals liable to long abstinence. In man and some other animals it accumulates internally to preserve the heat of the principal organs of life as age advances. It is found more abundantly in some parts than in others. In quadrupeds, and birds, and in the human body, it is deposited in pretty considerable quantity near the kidneys, under the skin, in the orbits of the eyes, in the epiploon, and sometimes at the point of the heart. In man there is none about the legs, the penis, and the brain. In the cold-blooded and cetaceous classes, the cavity of the cranium forms one of it's reservoirs, and it is mixed with the parenchyma of the liver. According to Fourcroy, it is found in reptiles, insects, and worms, but in these animals it only accompanies the viscera of the lower belly, where it is placed in the form of knots, whilst on the muscles and under the skin, it is only met with in small quantities. It forms one half of the liver of the ray.

Having made these preliminary observations, animal oils may be divided into *spermaceti*, *fat*, *fish or thran oil*, and the *empyreumatic oil*, extracted by distillation from all animal substances.

*Spermaceti*. This white substance, improperly called *Spermaceti*. *spermaceti*, is a concrete, oily, crystalline matter, consisting of small shining semitransparent scales, very brittle, of a fatty flavour, and tallowy smell. It is found in very large quantities in the cranium of that species of fish called by Linnæus, the *physeter macrocephalus*; cacholot, by the French; and the *spermaceti* whale, by the English; it is likewise found in less quantity in the *physeter catodone*, *micrope*, and *curfione*.

Since this matter in it's natural state is mixed with a good deal of oily substance, the custom was to put it into a woollen bag, and let the fluid part run through, or make use of pressure, whilst the more fixed oil was converted into a soap by means of alkaline ashes and lime water,

Methods of  
extraction.



and then washed until the spermaceti was deprived of all foreign parts, and became perfectly white. It is purified by liquefaction, and melts at  $105^{\circ}$  of Fahrenheit.

It's singular  
properties.

The chemical properties of this substance appear to be very singular, since on the one side they make it resemble the fixed oil, and on the other the volatile. It melts at  $35^{\circ}$  of Reaumur, which property makes it very convenient to convert into candles, the more so, on account of it's burning with a very clear white flame, without any bad odour. In North America very large quantities of

Manufac-  
tures.

these candles are made. We are informed by Fourcroy, that a few years ago, Lepelcheux established a manufactory of this kind in the Rue l'Echiquier, Fauxbourg St. Denis, at Paris; the process he makes use of consists in letting the fish oil repose in wooden casks lined with lead, and at the bottom of these casks, masses of spermaceti are precipitated, which, previously dissolved in the animal oil, separate from it gradually by a real crystallization. In proportion as this precipitation takes place, the oil becomes clear, is purified, and much more proper for lamps; when the oil is very clear, it is decanted; the spermaceti taken from the bottom, is pressed in order to separate a portion of oil which adheres to it, then melted by a gentle heat, and several times submitted to pressure and fusion, until at length it becomes white, crystalline, and of

Formed in-  
to candles.

a silver colour. In this state it is moulded into different kinds of candles, which are of a splendid whiteness, and of a much more beautiful transparency and brilliancy than wax. They are also manufactured in England. Exposed to a warm air, spermaceti becomes yellow and rancid, but less easily than the other concrete fixed oils. The water in which it has been boiled, on evaporation, gives but a slight mucoso-unctuous residue.

Discovered by  
Neumann.

Neumann appears to have been the only one of the older chemists who had chemically investigated this sub-

stance; he found on distillation, that it went over without leaving any residue, and afforded not a brown, empyreumatic, stinking oil, but a butyraceous one, which coagulated in the cold. According to Thouvenel, who seems to have appreciated in some measure the relations and differences of this concrete substance with respect to the other solid oils; it affords no acid phlegm like fixed oils, but passes over entirely, and without undergoing any change, into the receiver, from the time it begins to boil, leaving in the retort a carbonated trace. By repeating this operation, it loses it's solid form, and remains fluid, without being any longer volatile. According to Macquer, it gives the same products as butter. According to Crell, who has, by many experiments made on this substance, added greatly to the knowledge of it's nature and composition, he found, that by distilling some good white spermaceti on a sand bath, it acquired a greater heat to make it pass over than what is necessary for fat; and that he obtained a coagulated oil which appeared partly white, partly of a brownish colour; that on repeated distillation, it afforded a yellowish acid, became in part more fluid, but coagulated again by degrees on repose, by which it differed from the oil obtained from fat. The acid which by distillation became colourless, united with alkalis and calcareous earth, and afforded the same neutral salts as the sebacic acid; whilst the oil, mixed with caustic ammonia, afforded a species of soap.

Neumann had alleged, that the alkalis, even in a caustic state, had no action on spermaceti, and it was in vain he attempted to convert it into a soap. Lewis was of the same opinion; and Spielmann agreed with them in it's affording no soap. Crell, however, who perceived a great similarity between spermaceti and fat, thought, contrary to the opinions of the above chemists, that it might be converted into a soap; and he succeeded so as to form a

Action of  
alkalis upon  
it.

soap, by uniting it with the vegetable alkali; it had however a much milder flavour than the common sort. It is found, that this soap becomes solid by degrees even to friability.

**Acids.**

Although it has been said, that acids had no effect upon it, yet the concentrated vitriolic acid dissolves it, changes it's colour, and the solution is precipitated by water, like the oil of camphor. Achard likewise obtained a spermaceti soap by means of the vitriolic acid in it's diluted state, which was decomposed by the calx of lead, and by lime; but neither by lead nor tin, nor by distilled vinegar.

**Sulphur.**

We are informed by Fourcroy, that it unites to sulphur like the fixed oil.

**Oil.**

Volatile and fixed oils dissolved it by the aid of heat.

**Alcohol.**

It is also dissolved by alcohol when warm, from which it falls down on becoming cool. It was found, that one oz. 5 drachms of alcohol at  $38^{\circ}$  of the areometer, took up 6 grains of spermaceti, but on cooling, the whole was precipitated.

**Æther.**

Æther dissolves it without heat.

Such are the properties which spermaceti presents to the chemist, as it exists ready formed in animals. A further investigation of this substance however proves, that it is not peculiar to the cetacea class; and hence that it's

Several species of spermaceti.

name is now misapplied. From the experiments, more particularly of Fourcroy, it appears, that this concrete oily body forms a genus in the animal kingdom, of which there are several species. It appears, that it is even very abundant in it, forming an oil which peculiarly belongs to it, since nothing of a similar nature has been discovered amongst vegetables. These species, as Fourcroy calls them, are found to be produced either by the natural decomposition of animal substances, by the effects of disease, or by the artificial means which chemistry affords.

1st. The first species of spermaceti is that *peculiar con-  
creasible oil*, which Fourcroy found to be united in dif-  
ferent proportions with ammonia, so as to form a fat soapy  
matter in the common pits of the churchyard of the  
Innocents, at Paris. It appears to be very different from  
all other known oily bodies. This concrete oil separates  
spontaneously from the ammonia by the heat of the at-  
mosphere, and is found isolated in lamellæ or yellowish  
pellucid fragments in the masses of soap exposed to the  
air. It may likewise be separated by means of acids,  
and it was in this manner that Fourcroy obtained it, in  
order to examine it's properties. When separated from  
the fatty soap by acids, it always retains, more or less, the  
water either of the soap or acid, which being lodged be-  
tween it's particles, gives it a more or less white colour,  
a granular texture, and great lightness; and this character  
is much better marked in it, than in any other species of  
oil hitherto known. This extreme avidity to retain wa-  
ter appears to belong to the primitive soapy state of this  
substance; a part of it is, however, to be separated either  
by fusion or by exposing it in small flakes to the dry air,  
and if it be again melted, after this last experiment, it  
is commonly much less white than before, and loses it's  
granular texture. The degree likewise of concentration  
of the acids employed to separate it, changes it's proper-  
ties. In general, every acid that is weak and diluted with  
water varies it's properties. Concentrated sulphuric acid,  
by exposing a portion of it's carbon, renders it blackish,  
of which hue it cannot afterwards be deprived. Strong  
nitric acid gives it a lemon colour, which it preserves a  
long time against the action of the air and light. The  
muriatic acid leaves it unchanged, with it's white colour.  
The acetous acid the same. To procure this substance as  
white as possible, the soap must be first dissolved or tem-  
pered with 12 times it's weight of hot water, and then be

1. That pro-  
duced by  
putrefaction.

It's great  
avidity to  
retain water.

Acids vary  
it's proper-  
ties.

Method of  
bleaching it.

decomposed by the acid. The concrete animal oil thus prepared, appears to be very white as long as it's flakes retain water, but in proportion as they become dry by the contact of the air, or especially when melted to be united in one mass, it then becomes of a brownish or yellowish grey colour, and this shade appears in almost all the operations it is made to undergo. Fourcroy attempted to bleach it by exposure to the air, without effect, but the oxygenated muriatic acid in large quantity kept in contact with it 60 days, gave it a sufficiently beautiful white colour, which however soon dissipated on melting, and was replaced by the dirty yellow shade.

It's properties.

Compared to spermaceti and wax.

With respect to the properties of this concrete oil, it is of a granular texture, and soft to the touch when it contains water; on being pressed between the fingers, the grains separate by giving way, but by the heat of the hand it soon becomes ductile. When dry, and deprived of water, it is of a lamellated crystalline texture, if suffered to grow gradually cool; if it becomes suddenly cool it's grain is compact; in the first case it resembles spermaceti, in the second it is analogous to wax; hence the reason of it's being called by both these names. In both states of crystallization, whether granular or lamellated, when well dried, it is sonorous, breaking with a snap like wax; the first of these analogies however is much better pronounced than the second, and it is with spermaceti that it has always appeared to Fourcroy to have the nearest relation. Like it, it is smooth, greasy, and unctuous to the touch; it has neither the dry nor the hard feel of wax; it does not break as wax does, but is lamellated and shining like spermaceti; it is not ductile like bees wax, but crushes like the other. It melts however at a less heat by  $3^{\circ}$  than spermaceti *i. e.* at  $42^{\circ}$  of Reaumur. It also became cool and fixed much sooner, was harder, and more sensibly brittle. Well purified and washed, it has scarcely any odour,



whilst spermaceti has a peculiar one. Like spermaceti, it is soluble in alcohol by means of heat; but in proportions and with appearances somewhat different. One ounce of alcohol between 39 and 40° of Reaumur's areometer dissolved at the boiling point 12 drachms of this concrete oil, whilst the same quantity of alcohol at the same temperature, only dissolves from 30 to 36 grains of spermaceti. When the alcoholic solution of the first is cool, it becomes a concrete granular mass, in which the liquid alcohol is not seen. If the proportion of this last be increased so that the concrete oil only makes  $\frac{1}{4}$  of it's weight, this matter separates in grains or crystalline flocks, and there only remains a scarcely perceptible quantity of it in the cold alcohol. Spermaceti, likewise dissolved in alcohol, is precipitated on cooling, but it's separation takes place much sooner, and it takes a much more regular and crystalline form.

Ammonia dissolves this concrete oil with singular facility, and even in the cold, whilst spermaceti is not at all dissolved by it in the cold. By heat, this alkali forms with it a very frothy soap, the solution of which is clear and transparent, but spermaceti never produces this effect even when the ammonia is in excess.

It appears, therefore, that this concrete oil resembles spermaceti in it's form more than any other oily substance, but that it differs from it in it's very tenacious colour, it's greater fusibility, it's property of retaining water, it's being twenty-four times more soluble in alcohol, and in ammonia. These last qualities, as well as it's sonorous brittle quality; and it's often granular texture, give it a resemblance to wax; it may therefore be called adipoceros matter.

A concrete oil, analogous to spermaceti, was likewise extracted by Fourcroy from a piece of a human liver given him by Poulletier de la Salle; it had been suspended in the open air for ten years, and was become

Ammonia  
dissolves it.

Has the  
name of  
adipoceros  
matter.

A similar  
substance  
extracted  
from liver.

dry, after having undergone a state of putrefaction. From the experiments of Fourcroy on the liver, he found that alkali dissolved a part of it, and formed with it a soap. That alcohol dissolved a part also of it, which on the addition of water deposited a *white flaky substance*. This substance, deprived of a small portion that was soluble in water, was of a yellowish colour, soft and greasy to the touch, like a concrete oil; water melted it under a boiling heat, but did not take away its colour. It had then a slight odour like melted wax. On being cast into a porcelain cup, it became fixed into a solid brittle cake, of a polished surface, and snapped on breaking. Its internal texture was lamellated and manifestly crystallized. Heated alcohol completely dissolved it, and it presented all the properties of spermaceti, with this only difference, that it was not so dry, white, and transparent, but more soluble in alcohol than spermaceti. This appeared to be in a state of soap in the liver, for water likewise extracted it by means of heat, and the oil was afterwards rendered concrete on cooling, but the small quantity of liver prevented this chemist from making any further experiments. Vanquelin likewise extracted an oil from the liver of the skate, which became white as fat and as thick, and very similar to wax that had been kept warm between the fingers for some time.

2. By disease.

In biliary calculi.

2d. Having given some account of this concrete oily matter produced by putrefaction, the second species comprehends that produced by disease, as in the biliary calculi; for the chemical investigation of which we are likewise indebted particularly to Fourcroy. It is observed, on treating on biliary calculi, that Poulletier, on dissolving some in alcohol, found that it deposited a lamellated brilliant substance, resembling boracic acid. It is this matter that Fourcroy found to have a great analogy to spermaceti. Having dissolved part of some of these cal-



culi in alcohol by means of heat, on cooling, he found the solution deposited a great quantity of white brilliant crystals, which were the concrete oil to be examined. Having exposed them to heat, they soon melted, and formed a yellow, unctuous, roapy liquor, very small in bulk to what they were before; this liquor exhaled an odour like wax. On continuing the heat, a penetrating white vapour arose like that from a roasted oil; on cooling, it became a concrete, brownish, dry mass; brittle, and in its fracture presented a laminated, and polished structure, which announced a crystallization, or at least a remarkable tendency to it. These phenomena succeed each other very rapidly, and by a very feeble heat. If this crystalline matter be heated suddenly, and strongly, it becomes entirely converted into vapours, and only leaves a brownish yellow spot in the silver spoon in which it is melted.

Method of  
obtaining it.

Water has no effect upon it; in boiling water it melts and rises to the top like an oil, and becomes concrete again, on cooling.

Action of  
reagents  
upon it.

Liquid, caustic, fixed alcalis, dissolve it in the cold, and form with it soaps.

The nitric acid dissolves it without heat or effervescence, forming a solution that resembles *oil of camphor*. It is decomposed by water, and flakes and lamellæ are separated in their former state.

Alcohol when hot, dissolves a large quantity; according to Poulletier, one oz. 5 drs. and 12 grs. of alcohol dissolved at 60° of Reaum. 50 grs. of this white crystalline matter; but the greater part separates on cooling. It was these last results that convinced Fourcroy of the striking analogy between this substance and spermaceti. Calculi of the gall bladder are even found in some cases to be totally formed of this concrete oily matter; for which see article *biliary calculi*.

Forms biliary  
calculi.

3. By nitrous acid.

3. Besides the conversion of animal substances into a concrete oily matter, resembling spermaceti, by means of natural decomposition, and that brought about by distillation, it has been found by Gibbs, that the same conversion takes place by the nitrous acid; and the concrete oil obtained, has precisely the same characters as that obtained by water, *vide* putrefaction. That which he obtained from human muscle was melted, and the thermometer rose, when plunged into it, to  $160^{\circ}$ ; it congealed at  $112^{\circ}$ , and became solid at  $110^{\circ}$ ; whilst spermaceti of the shops, under the same circumstances, when fused, forced the thermometer to  $170^{\circ}$ ; at  $117^{\circ}$  a pellicle was formed on the substance, and it became perfectly solid at  $114^{\circ}$ .

Compared with spermaceti.

A piece being dissolved in boiling spirit of wine, the mixture let fall a great quantity of this waxy matter in the form of beautiful flakes; large crystals could not be procured, but the flakes assumed a crystalline appearance.

Distilled.

A small quantity was put into a copper retort, and placed on a common fire: at first, there came over a limpid fluid like water, without much smell; by a stronger heat, an oily fluid arose which soon coagulated; it was of a firmer consistence than when put in, and coloured of a beautiful green by the copper; which last circumstance, he thinks, proves that it contained no ammonia.

Some of this waxy matter was put with some finely levigated charcoal into an earthen retort, a strong heat was applied, when a small quantity of an oily fluid came over, which concreted on cooling; after which came over a prodigious quantity of thick white vapours, very suffocating and offensive.

The nitrous acid converts flesh into this substance in three or four days, and he found that when this sebaceous matter was produced from the human subject, it

assumes a very beautiful and regular crystalline appearance, whilst that from quadrupeds seems not disposed to crystallize.

After the conversion by water, this substance has a disagreeable odour; and although the nitrous acid takes off the greatest part of the fœtor, it gives it a yellow colour and the smell of the acid, which mere washing, and the addition of alcalis, will not entirely remove. In order to whiten this substance, the following process will make it very pure and beautiful, but not so white as the spermaceti of the shops. It is broken into small pieces, and exposed for some time to the combined actions of the sun and air, by which it loses a great deal of its smell, and acquires a firm consistence. It is then powdered, and weak nitrous acid poured upon it; in an hour a froth is formed, and the acid is decanted, and the substance repeatedly washed, then melted in hot water, and when cool, is concentered, and is of a beautiful straw colour, and has the agreeable smell of the best spermaceti. This might be made use of in the arts.

Method of  
bleaching it.

It may be proper to observe here, that previous to the experiments of Gibbs, Berthollet had already used the same method of separating animal oil from the different parts of animals. He extracted the nitrous acid from these substances, but not in less quantity than is sufficient to obtain the oxalic acid, which is from seven to eight parts, and this afforded him a fat matter. Of these substances, gelatin gave him the least fat; silk, wool, and hair, the most. A small quantity went over with the acid, coloured it yellow, and gave it the smell of animal oil. This fatty matter was not, however, in a concrete state.

This conversion of animal substances into this concrete fatty matter is said to arise by depriving them of their azot; but with respect to the utility of the knowledge of

The conversion  
is ac-  
counted for.

these changes, the matter may be either converted into soap, or manufactured into candles, as it burns with a fine flame. By comparing, therefore, spermaceti with the concrete oil separated from the soapy matter of inhumed bodies, with that separated from the dried liver, and with that which exists in abundance in biliary calculi, Fourcroy has, it appears, found differences in the forms, dryness, fusibility, and solubility in alcohol and in æther, which are very remarkable, but which have not prevented him from making the resemblance, and from considering them as matters of the same genus, differing only in these specific characters; whether these, however, are specific differences, or only varieties, further observations must prove. It remains therefore to determine,

A further investigation required.

1st. The real composition of these concrescible, crystallizable oils, which are neither butters, suets, nor waxes; which do not exist in vegetable substances according to their present analysis, and which differ from the concrete oils of plants, as the liquid oils of animals differ from the liquid oils of vegetables:

2d. The diversified composition of these species which constitute this newly distinguished genus of crystallizable animal oils, their relations between them and the liquid animal oils, and their formation. These discoveries appear now within the reach of chemistry, and no doubt will be effected by those who undertake the labours they require. Fourcroy has already begun the investigation, by treating the oil extracted from bile, (which has been falsely looked upon as a resin) by the oxygenated muriatic acid, and he has converted it into a dry and concrete substance, analogous to spermaceti. The slow decomposition of solid animal substances, inhumed in a mass, prove also by the conversion of the muscles and ligaments into fat, that the fibrous, albuminous, and gelatinous

matter may pass into a congealable oil. It will likewise not be forgot, in the analysis of spermaceti, and the animal congealable oils that resemble it, to investigate the cause of it's being so abundantly formed in the cetaceous class, and the use of it in the cavities of the cranium, and in the spinal marrow, and the reason why it is found in greater quantities in animals that breathe little than in those which respire much, *i. e.* in warm blooded animals, and why in these last this concrete oil appears only to reside in the liver and the bile, whilst it exists so universally in the animals with cold blood.

*Fat.*—This is a fixed oily secretion, which in point of <sup>Fat.</sup> consistence appears to hold the medium rank between spermaceti and the fluid oils; it is not so concrete as the one, and more so than the other. It is formed at the extremities of the arteries, according to the best authors, and at the greatest possible distance from the centre of muscular motion, and of animal heat, by which means it presents a species of reservoir where a great quantity of hydrogen, not evacuated by the lungs, becomes fixed.

In young animals it is of a white colour, and has a mild insipid flavour, but in adults it very often tends to a yellow colour, and as age advances it's colour becomes deeper and it's flavour stronger.

To obtain it pure, and fit for chemical experiments, it <sup>How purified.</sup> must be cut into small pieces; the membranes and small vessels are then separated; it is washed in a large proportion of distilled water, to deprive it of all it's gelatinous part, kneaded by the hand and the water, renewed until it becomes insipid and colourless; the fat is then to be melted by a moderate heat in a glass or new earthen vessel, together with a little water, which when evaporated, the boiling noise of the fat in fusion ceases. It is then to be poured while hot into another vessel, where it fixes on cooling and becomes solid. The use of the water added to the



fat, is to prevent it's roasting and becoming black; it likewise forms a species of water bath, rendering the heat more equal; but it is necessary not to let any remain, as it would hasten it's rancidity. This is known by dropping a little of it on some red hot coals, where it burns without crackling, if it retains no humidity.

Fat when thus purified, is white, nearly inodorous, or has rather a weak aroma that is peculiar to it; it's flavour is mild, and oily, and in this state it approaches very much to the fat vegetable oils, as those of olives, benzoin, &c. which have no resinous or gummy properties, and are not ficcative.

Examined  
by the mi-  
croscopy.

Fat when examined by the microscope, is said to exhibit a number of yellowish vesicles, formed of a very thin and transparent pellicle containing an oily fluid. These vesicles differ in size in various animals; according to Wolf, the fat of the pullet is contained in smaller vesicles than those of any other animal, whilst the vesicles of the goose are larger, and arranged with more regularity. The next in order are the human; but the most considerable are those of the hog. It's only reservoir, according to Scopoli, is the cellular membrane.

It's analy-  
sis.  
Neumann.

With respect to the chemical analysis of fats, Neumann, from his distillation of the fat of the goose, the pig, the sheep, and the ox, from which he obtained an empyreumatic liquor, brown oil, and charcoal; and from his other analyses, concludes, there is but little difference in fats; that the fat of the ox only appeared to contain a little more earthy matter. He looks upon them as a physical mixture of oily, gelatinous and aqueous parts, with a little earth, and some saline parts interposed.

It is scarcely necessary to observe, how far the experiments and observations of this chemist are distant from the present precision of chemical operations. He takes

no notice of the loss of one part into it's aeriform elements, and decides without any examination, that the coaly residuum, or the caput mortuum, as he calls it, is an earth; whilst it is now well known, that the carbons of animals which so powerfully resist incineration, contain the phosphoric acid. It is less astonishing that he takes no notice of the acid, for Macquer has confessed, <sup>Macquer.</sup> that although forewarned of the said production from distillation of blood, by the observations of Homberg, he was on the point of concluding that this chemist was deceived, because the presence of the oil prevents this acid from acting on blue paper, and the part touched only became red on beginning to dry; and this is most probably the reason why so many chemists have erred respecting the real nature of one of the products of the distillation of animal substances as well as vegetable.

Hoffmann was of opinion, that the saline principle of <sup>Hoffmann.</sup> fat and animal oils was purely alkaline, in which they differed from vegetable oils; and advanced as a proof, that these last occasioned a green rust in copper vessels, whilst fat on the contrary, when kept a long time in the same, gave them a beautiful blue colour; an effect according to this author that could only be produced by an alkaline principle: this argument however is now proved to be false, as it is well known that this colour only depends on the more or less oxydation of the metallic calx.

Vogel had a much better knowledge of the empyreu- <sup>Vogel.</sup> matic oil extracted from fat by the fire, and acknowledged the presence of an acid saline principle; but the experiments of later chemists, as Segner and Crell, leave no longer any doubt on the subject.

According to Plenck, fat is nine times lighter than dis- <sup>Plenck.</sup> tilled water. It requires for it's fluidity a greater heat than olive oil, which is fluid at 40° of Fahrenheit's thermometer, and a less heat than yellow wax, which melts



at 140°. It contains no parts so volatile as to be forced over at a boiling heat, and it only inflames at a temperature that converts it into vapour.

**Distillation.** If fat be distilled by exposing it in a retort to a greater heat than that of boiling water, there first comes over an acid water, and a small quantity of oil, which remains in a fluid state; on continuing the heat this acid becomes stronger (*vide* sebacic acid), and the oil always less fluid; but the degree of heat must be strong enough to prevent the coagulation of the oil, so that one drop may immediately succeed another.

If the oil, which has a very nauseous smell, be submitted to a second distillation, it becomes more fluid, and at each rectification an acid spirit is separated, and a coaly residuum left behind. Its smell becomes more penetrating, and by repeating the distillations, it may be brought to have the volatility of essential or ethereal oils, and to evaporate at the heat of boiling water. By repeated abstraction and edulcoration by water, it is so deprived of its acid, that Crell obtained it so pure as to be volatile at a less than boiling heat. Hence it appears, the fat derives its consistence, and also its fixedness, from the acid, from which it can only be separated by repeated distillation.

**Crell.** According to Hildebrandt, if the sharp vapour which arises on the acid coming over catch flame, it produces a good deal of smoke and soot. By the dry distillation it affords hydrogen and carbonic acid gases, and the oil which before was yellowish becomes dark, and at last of the consistence of pitch. When the iron is red hot there remains a little coal of difficult incineration. Crell having by an excessive and long continued heat incinerated this coal, found the ashes to be of a lightish red colour, which when lixiviated with distilled water and evaporated, gave a salt of no determined shape or flavour, did not

deliquesce in the open air, but dissolved in water, and a little vitriolic acid added deposited gypsum. This earth however left behind it it's constituent part, an acid, which after evaporation, appeared a white, dry, acid salt, that melted before the blowpipe into a transparent globe; and mixed with foot, and exposed to distillation by a strong heat, emitted a phosphorescent light, consequently it was the phosphoric acid. Besides the discovery of this acid in the ashes, Crell found they contained calcareous earth in a free state. In distilling fat, great care must be taken to avoid the sharp, penetrating and volatile acid vapours that arise, otherwise they irritate and inflame the eyes, the throat, and the lungs; they not only force tears, but excite a cough as bad as sulphureous vapours.

It is insoluble in water.

Action of  
water.  
Acids.

Acids form soaps with fat, as with the fat vegetable oils. Achard formed soaps of this kind with the vitriolic acid and the oil of the yolk of the egg, as well as train oil, which he found to be decomposed not only by alkalis, but by acids; according however to Leonhardi, distilled vinegar does not effect a decomposition. By the nitrous acid, with a certain degree of heat to produce a decomposition of fat, the acid of sugar is obtained.

Alkalis, particularly when caustic, as well as caustic Alkalis, earths, likewise form soaps with fat, which are decomposed by acids.

Alcohol has no solvent power on fat, except in it's Alcoholic rancid state; it then dissolves the rancid part.

Fat, like oils, dissolves sulphur and phosphorus; it has Solvent power of the same power on metallic calces, particularly those of iron and lead; it attracts quicksilver by means of trituration; unites with the regulus of arsenic by ebullition, and enters into the composition of plasters; it soon rusts copper, which proves the danger of letting it remain in vessels of that metal; and Fourcroy is of opinion that

it even acts on the glass of lead with which pots are glazed.

Extracts and mucilages render fat soluble in water.

It unites with oils in all proportions, and increases their consistence.

**Rancidity.** Fat in it's natural state has it's acid so intimately united to it's oily part, that none of it's properties are to be discovered; hence arises the mildness of this oily substance. But it has been before observed, that when by a sufficient degree of heat a decomposition extricates this acid,

**Changes the properties of fat.** it's properties are entirely changed, it becomes sharp and irritating. The same thing happens when fat has been exposed for some time to the atmosphere; a partial decomposition takes place, a little of the acid becomes extricated, the colour becomes brownish or yellowish, and the taste and smell are sharpish and disagreeable; and this state is called *rancidity*. It is likewise found different

**Becomes soluble in alcohol.** in it's chemical properties; for alcohol, that in it's mild state had no effect upon it, now dissolves the rancid part, leaving the rest untouched. De Machy, a Parisian chemist, has, therefore, very properly observed, that by means of washing in alcohol fat may be deprived of all it's rancid part, whilst it leaves the sound part. Pœrner proposes, as a more economical plan, to deprive it of this *rancidity* by mixing and boiling it with fresh spring water, to skim it, and repeat the operation. Macquer proposes to add a little calcareous earth or alkali to the water, the better to absorb the acid of the *rancidity*, and afterward, byedulcoration with a large quantity of pure water, carry off all the saline or soapy matter that may have been formed.

**Various methods to deprive it of its rancidity, and opinions on the cause.**

These observations appear to Morveau to admit of no doubt, but that the acid developed puts the oil, no longer a perfect fat, into a state of soap, otherwise it could not be extracted by water alone, whilst the properties of

the unchanged fat would to a certain point be altered. Fourcroy is of opinion that this change in fat arises from the fermentation of a peculiar animal mucilage, of which fat always retains a certain portion intimately combined with it, and that the rancidity proceeds from the extrication of the fixed air. On this supposition, the addition of <sup>From fixed</sup> fixed air must correct the rancidity; and Sieffert informs <sup>air.</sup> us this was done by mixing sweet fruits or honey with rancid oils, so as to occasion a fermentation, and a production of fixed air, which restores to them their gas. Rozier and Cettinger have confirmed this observation, and even have corrected, and meliorated fat, and rendered it sweeter and firmer by putting apples, or other fruits, into the pot in which it was melted. Rozier even recommends a sponge to be dipped in a mixture of alum and chalk, and to be placed at the bottom of the oil vessel, by which means the acid of the alum will extricate the fixed air from the chalk, which will mix with the oil. It appears that Morveau even is not far from admitting a sort of fermentation in fat, *i. e.* a more or less sensible motion determined by the affinities of the air, and the heat, producing new combinations: in short, he thinks it very probable that oils change in the manner acids do; that a new portion of the acidifying principle unites to them in the same way, which last is proved from the experiments of Haffé; and Scheele precisely says, that the air is diminished by oils which become resinous: Morveau, however, confesses that much is wanting to conciliate this theory with all the phenomena.

1st. It supposes an animalization in fat, which is opposed by facts. 2d. Recent fat, distilled in closed vessels, undergoes a change perfectly analagous; some developped acid is also formed: hence it must be acknowledged, that the acidifying principle preexisted in the fat; that it was there in sufficient quantity instantly to produce

that change which the access of air produces in a length of time; or it must be said with the celebrated Scheele, that the vital air may proceed here from the decomposition of the matter of heat. Fat is likewise soluble in alcohol, after it has been precipitated from soap by means of acids.

It would be of use to examine what influence the sweet saccharine matter, which Scheele found in oils, has upon their rancidity. It is said, that if fat or butter be boiled with half the quantity of litharge in water, to the consistence of salve, the water becomes sweet, and by evaporation is converted into a syrup. This contains nothing if the oil be mild, but if rancid, a little of the litharge, which is precipitated from it by vitriolic acid. By a stronger heat, an inflammable vapour arises, and it requires, to be forced over, the boiling heat of oil of vitriol; it then comes over in part undecomposed, having it's sweet taste, whilst the other part is empyreumatic, and is converted into a brown oil, with a smell of alcohol; a light spongy coal remains, containing no calx of lead. By repeated distillation, it appears to undergo a further decomposition, and with a little spirit of tartar, to become sharp and bitter. This sweet fluid does not crystallize, nor ferment when mixed with water and placed in warmth. It mixes with the sharp tincture of tartar without attracting and falling down with it, as honey does. By repeated abstraction of nitrous acid, it is at last changed into acid of sugar, and appears, according to this chemist, to contain more phlogiston than even sugar or honey.

Sebaceous  
acid.

The acid of fat which causes it's rancidity, is likewise the cause of it's fixity; hence the sebaceous substances are like particular oils that owe their consistence and fixity to the same cause. As a proof of this, according to Pœrner, if the oil of almonds be digested for a little time with a



small quantity of nitrous acid, a substance resembling fat will be obtained.

That the different consistence of fats is owing to the proportions of the sebacic acid with the oily parts is also proved, from the comparison of the quantity of these products in Crell's experiments on human fat, and the suet of the ox. In short, it is to the intimate union of different proportions of this acid with the oil, that the greater or less fixity of them is to be attributed; and that, in proportion as this principle is taken away, they become fluid and volatile, resembling essential oils, is evident on distillation, where the more the fats are deprived of it, the more fluid and volatile they become, and rise at the boiling point. It appears however that this acid is more intimately united in animal oils than in any other, as they are much longer in becoming rancid; and submitted to repeated distillations, very little acid is extracted at each process, hence they are the most difficultly made fluid and volatile.

It is the opinion of Morveau that this sebacic acid exists perfectly formed in fats previous to distillation, since these substances exposed to the fire in close vessels give their vital acidifying air in a state of mephitic gas; besides, according to this chemist, the state of the carbonaceous residue, which resembles plumbago, from its difficult incineration, announces a considerable quantity of vital air fixed in this residue, and converted into mephitic acid. In short, it appears (article sebacic acid) that the separation of the acid, and of the oily portion, may be effected by the moist way, without the aid of heat, a demonstrative proof of its being already formed. The manner, however, in which these two parts are united, since they cannot be recomposed, shows it is not a simple combination, but one which further experiments must explain.

The consistence of fat owing to the last acid.

It exists perfectly formed in fat.

Gren and Ricchen inform us, that they have at length perfectly decomposed fat by repeated infusion and digestion, with moderately strong nitric acid, into oxalic acid and vinegar.

Various  
kinds of  
fat.

The various kinds of animal fat that have undergone any chemical investigation, are *human fat*, *suet*, *marrow*, *lard*, and *butter*.

Human fat.

*Human fat.* Rhades was the first who examined human fat, but very little can be collected from his experiments; it is to Segner and Crell that we are indebted for what little is known of it, as well as of the greater part of other fats. Its specific gravity is to water as 0,903 to 1000, and it is fluid at 84° of Fahrenheit.

Experiment  
of Segner;

On distillation, this fat afforded nothing at 450° of Fahrenheit, and very little at 550°; it was only at 600° that there passed over 100 drops of phlegm, and a great proportion of oil: from four ounces, six drachms of a very thick oil remained in the retort. This phlegm appeared to give the syrup of violets a reddish tinge; the smell was strong, and so insupportable that its nature could not be determined; it had a very empyreumatic, sharp, somewhat acid flavour. The remaining oil was of the consistence of honey, of a sweetish taste, and a slight empyreumatic odour. The phlegm effervesced with the solution of potash; on saturation, it had a saline taste, and gave on evaporation a thickish, yellowish liquor. On examining some friable, irregular parts, they appeared to have a crystallized form. This dried mass exposed to the air returned to a saline, sharp, and bitter liquor, not alkaline.

of Crell.

According to the experiments of Crell, in a memoir expressly written on the constituent parts of this fat, it appears, that 28 oz. of it, being previously melted and filtered, when distilled on the sand bath, melted at 155° of Reaumur's thermometer, and there came over a little insipid phlegm. The distillation then stopped, although



the heat had been increased  $45^{\circ}$ , but being augmented beyond  $220^{\circ}$ , the mass began to swell exceedingly, so as even to rise into the neck of the retort, which is not the case with *ox fat*. At the same time there passed over a liquor accompanied evidently with vapours, which when collected in the receiver appeared to be of two kinds; that at the top was a brown red oil, the colour of which became by degrees deeper, and beneath this was a phlegm of a golden colour. At the bottom of the receiver there was a fixed oil resembling that from wax: the heat being increased until nothing more came over, the operation lasted 21 hours. At the mouth of the receiver, a very penetrating odour was perceived, although less lively than that from *ox fat*. The liquors being separated, there were found  $2\frac{1}{2}$  oz. of black oil, and 1 oz. 7 drachms of a yellow acid phlegm. There remained in the retort a shining, friable coal, weighing 1 oz. 2 drachms, 2 scruples. The fixed oil melted, and distilled again by a heat of  $200^{\circ}$ , afforded 9 oz. of oil less coloured than the first, 1 oz. of yellow acid, and more fixed oil. This oil being twice again distilled, this chemist received by the same heat, the first time 7 oz., 6 drachms of a reddish yellow oil, and 3 drachms 30 grains of acid. The last time, the heat being carried to the most violent degree, there were found in the receiver 1 oz. 3 drachms, 40 grains of brown oil, and only one drachm of acid. The carbonaceous residues were of the same nature as the last, and weighed one ounce 7 drachms. Thus 28 oz. of human fat, on being decomposed by distillation afforded,

	oz.	dr.	gr.
Of fluid oil .....	20	5	40
acid phlegm .....	3	3	30
charcoal .....	3	1	40
Lost during the process	0	5	10
Total ..	28	0	0

To separate the acid that might adhere to the oil, this chemist agitated it at several times in water, and separated it by a siphon; the waters being collected were saturated with 1 drachm 7 grains of potash, and as it requires  $6\frac{1}{2}$  drachms of this alkali to saturate 30 grains of the acid, he concluded, that these waters had still given  $14\frac{1}{2}$  drachms of acid.

The brown oil redistilled by a gentle heat afforded a volatile, clear oil, of an aromatic flavour; on increasing the heat it became yellow, and at last reddish. There remained 3 oz. 30 grains of charcoal.

Two ounces of this coaly residuum were with great trouble incinerated. The ashes weighed 5 drachms 30 grains. Boiling distilled water only extracted from them 4 grains of an insipid salt, and a little calcareous earth was precipitated by the addition of vitriolic acid. The nitrous acid on digestion deprived the ashes of their red colour, but the vitriolic only precipitated a little selenite. The liquor exsiccated, and the residuum calcined, became red, and amounted to 6 grains. This chemist regards this fixed salt as the same as what he got from the ashes of *suet*, *i. e.* the phosphoric acid. Of the 4 drachms of remaining ashes, the vitriolic acid on distillation took up 40 grains of aluminous earth, and the surplus, mixed with an equal quantity of fixed alkali, ran into a perfect glass.

It remains to be proved, whether the redness was owing to the presence of iron, and whether the argill did not come from the vessel. With respect to the glass, it is well known that the vitrification of bones depends on the phosphoric salt.

*Suet.*

*Suet.*—Ox suet, submitted to distillation in a sand bath, melts at from  $104^{\circ}$  to  $116^{\circ}$  of Fahrenheit; it afforded a good deal of oil, and but little phlegm: the odour arising from these products affects the head: acids had no effect

on them : they formed soaps on agitation with a solution of potash. The reddish phlegm had an acid taste, effervesced with an alkali, yet it did not redden the syrup of violets, but communicated to it rather a brownish tinge, which arose from the oily parts.

Distilled with unlixivated ashes it afforded no volatile alkali. The oil that came over was nearly black, arising from the great heat necessary to break the soapy union. The phlegm resembled spirit of tartar, did not effervesce with an alkali, and changed the syrup of violets green.

With potash suet likewise afforded a blackish oil ; the phlegm had an alkaline flavour ; it effervesced with the nitrous acid ; the alkali by means of the oil had reached the neck of the retort.

From two pounds of ox suet Crell obtained 14 oz. 1 drachm of fluid oil, 7 oz. 2 scruples of acid, and there remained of coal 10 oz. 6 drachms and one scruple.

Stag suet requires the same heat for fusion as that of the ox, and that of the sheep melts at  $124^{\circ}$ .

*Marrow.*—The marrow of the ox on distillation afforded similar products to suet, except that there passed at first into the receiver a white suet resembling the butter of wax. It afforded an insipid water, much oil, the greater part of which became fixed again, and very little phlegm ; also an acid was obtained. Marrow.

*Lard.*—Hog's lard on distillation afforded a brown fluid oil, but scarcely any phlegm ; a few grains of black matter remained in the retort. It melts at between  $99^{\circ}$  and  $100^{\circ}$  of Fahrenheit. The oil weighed nearly as much as the lard employed, had a weak empyreumatic odour, gave no signs of ammonia ; the taste seemed to indicate an acid, but it soon became bitter. This oil gave the syrup of violets an obscure colour tending to a green. Lard.

*Butter.*—When this inflammable part of milk is freed from all it's ferous and caseous matter, it is either of a Butter ;  
it's natural  
colour.

white or yellowish colour, according to the serum and the food and temperament of the animal; the more the plants are succulent and aromatic, as happen in summer, the more the butter will be coloured; and during the winter, when only hay or straw and bran are to be procured, the yellow colour disappears by degrees, and they afford only a dead white butter. This effect however does not take place in all animals, for the cow, the goat, the ass, and the mare, although nourished in the same pastures on the same nourishment, afford different coloured butters; the cow gives a yellow one, that of the goat and ass is much paler, whilst the butter of the mare is always white.

Artificially  
coloured.

Butter is artificially coloured by many substances, and as it is one of the best solvents for extracting the resinous colouring matters contained in certain plants, they are often made use of in the dairy. Thus, by beating the cream with the root of the orcanet, a colour is procured from the lightest shade to the deepest red, which cannot afterward be separated by water. This property of butter to load itself with the colouring matter on separating from the cream, Parmentier expected might extend to the green parts of plants; this was not however the case, but it received the aromatic parts. He found that when cream is beaten with a resinous colouring matter, it is the butter that is coloured, but when an extractive matter is employed, the buttermilk or serous part only remains coloured.

Savour.

Butter, when fresh, has a very pleasant and peculiar mild taste, although its taste, as well as its colour, depends on the food of the animal. If, for instance, it has been previously fed on turnips, or on grass with which garlick grows, or on cabbage, or various herbs the essential oil of which is strong and penetrating, the butter partakes of their flavour.

Aroma.

It is nearly void of smell.

It is more or less of a soft solid consistence; it is very solid from the milk of the goat and cow, and soft from that of the sheep; whilst from the milk of the ass, the mare, and the human female, it is nearly in the state of cream, more particularly that of the last.

When exposed to a moderate heat it melts and becomes transparent. According to Erxleben this degree is  $84^{\circ}$  of Fahrenheit; the fusion is perfect at  $88^{\circ}$ , and it remains somewhat fluid even at  $74^{\circ}$ ; it becomes solid again in the cold, but it is then somewhat granulated; in this state it keeps a long time without becoming rancid, but it has not that agreeable rich flavour it had before.

On distillation it affords a little insipid water, the sebatic acid, a yellowish fetid oil, called the oil of butter, and according to Scopoli, hydrogen gas. There remains about  $\frac{1}{2}$  oz of coal from one pound of butter. Several modern chemists are of opinion, that it is from the oxygen of the atmosphere that the formation of the acid arises. In the first distillation, however, this is unnecessary, because the quantity of oxygen in the butter is sufficient; but in successive distillations, Fourcroy found the external air necessary to convert all its principles into an acid; hence in a large apparatus a great deal is formed; on the contrary, in a small retort butter passes into the receiver, almost without alteration. Butter forms with potash a soap lightly solid, of a yellow colour and agreeable odour, easily soluble in water, and which perfectly cleanses all kinds of stuffs.

In a warmish temperature, or in more or less time, the sebatic acid is spontaneously separated from butter; it then acquires an acrid and rancid smell and taste, which is partly corrected by washing it in alcohol to take away the acid. Hence it appears that butter is very little different in its chemical properties from the fat oils of the vegetable kingdom.



It's particles give the yellow colour to milk. Vide *milk*.

*Oil of fish or thran, or train oil.* This is fluid, about the consistence of *fat*, and is very common in various manufactures, where it is employed for various uses. Few experiments have been made upon this oil. Dr. Priestley, has, however, informed us of some curious circumstances respecting it. They were in consequence of an attempt to confine the nitrous acid vapour by means of animal oils, and the oil he used was *whale oil*. He found that on mixing nitrous vapour and nitrous air with this oil it became hot, and was changed to a green colour; on cooling, it became red and coagulated; and when mixed with other oil, it separated from it and sunk to the bottom exactly like the ice of oil, and continued there without mixing with the rest of the oil. On making a quantity of alkaline air pass through the oil, saturated with nitrous vapour in order to mix it with some air that had issued from it, the oil, from being red, became almost quite black.

A part of the whale oil that had been used in his first attempts to confine the nitrous acid vapour, of a dark red colour, and coagulated, being melted and put into another phial, and then impregnated again with fresh nitrous vapour, became of a deep blue colour. In cooling, it became of a dirty green, then inclined to a yellow, became a little fluid, and continued so.

A quantity of *fresh whale oil* became blue by this mode of impregnation. On cooling, the upper part became stiff, and assumed a light orange colour, while the lower part still continued blue and fluid; but it became at length of a deep orange, and was perfectly coagulated throughout. The oil, about two months after impregnation, on being melted, retained the same colour and it's peculiar smell, though mixed with that of the spirit of nitre.

From his experiment upon this oil and others, he found that all oils readily decompose nitrous air as well as im-  
hibe nitrous vapour; that the effects of this impregna-  
tion is, that they are in general coagulated and become  
of a red colour; and that in all cases in which nitrous  
air is decomposed, Dr. Priestley found it is reduced to the  
state of phlogisticated air. It is in this way that he ex-  
plains the phenomena which took place in his experi-  
ments on the whale oil above mentioned. But the phe-  
nomena attending the processes, from the first to the last  
stage of impregnation, are very various and remarkable.

The first express mention of soaps occurs in Pliny, <sup>Animal</sup> and Galen; the former declares it to be an invention of <sup>soaps.</sup> the Gauls, though he prefers the German to the Gallic  
soaps: Pliny says that soap was made of tallow and ashes, <sup>Their anti-</sup> that the best was made of goats' tallow and the ashes of <sup>quity.</sup> the beech tree, and that there were two kinds of it, hard  
and soft. The author of a work (*De Simplicibus Me-*  
*dicaminibus*) on simple medicines, which is ascribed to  
Galen, but which Beckmann is of opinion was not  
written by that author, and of which a Latin transla-  
tion only has been printed, speaks of soap being made by  
a mixture of ox, goat's, or sheep's tallow, and a lye of  
ashes strengthened with quicklime. He says, the Ger-  
man soap was the purest, the fattest, and the best, and  
that the Gallic was next in quality.

This account corresponds more exactly with the pro-  
cesses used in Germany at present, while the French use  
mineral alcali, and instead of tallow employ oil, which  
appears to be a later invention. Pliny in his description  
does not speak of quicklime; but as he mentions a mix-  
ture of goats' tallow and quicklime a little before, it is  
probable that the lye of the latter was then known at  
Rome. Gallic and German soap are often mentioned by  
later writers as well as by the Arabians, sometimes on ac-

count of their external use as a medicine, and sometimes from their washing qualities.

Experi-  
ments on  
the making  
of soaps by  
Darcey, &c.

It has already been observed, that animal oils form soaps with caustic alcalis; it is only however in these countries where the climate will not produce the olive, that they are made use of in the fabrication of soap. Olive oil forms a soap far superior to animal oils; but they in their turn are preferable to the expressed oils of vegetable feeds. Some experiments on the fabrication of animal soaps have been made by Darcey, Lelievre, and Pelletier; the method they used, was to render the soda caustic by means of lime; they then boiled the alcali and oil together until the soapy matter began to separate, marine salt was then added to finish the separation.

They took eight pounds of suet, which, by uniting with caustic soda, composed a soap that weighed eight pounds fourteen ounces; it was of a good quality, of a white colour, preserved however a little odour of the suet; kept for three months and a half in a dry place, it had lost three pounds fourteen ounces, but had acquired a great degree of solidity.

By the union of three pounds of lard with caustic soda, a soap was formed that weighed eight ounces and half; it was very white and solid, and it's odour was not disagreeable. On exposure to the air for three months, it only weighed four pounds fourteen ounces. It was then very dry.

Three pounds of rancid salt butter, after being deprived of it's salt by water, formed a soap that weighed eleven pounds; it was very white, but retained a little of it's rancid odour. Exposed in a dry place it lost much of it's weight.

The same quantity of what is called horse oil (*huile de cheval*) at Paris, when united with soda, formed a soap that weighed seven pounds; it was white, and of a

good consistence. On exposure to the air for two months it lost two pounds. It had no disagreeable odour, and acquired great solidity.

A similar quantity of whale oil united with soda weighed five pounds; it was of a dirty grey colour, and had a disagreeable odour. On being kept two months in a dry place it lost eight ounces of its weight; but it had acquired so deep a brown colour externally, as to appear red. It was of pretty firm consistence, but not dry like the olive soap. Soaps made of fish oil, and of the oil of the cod fish, greatly resembled it.

Henry made some experiments to try the action of <sup>Metallic</sup> metallic oxyds and earths upon oils, in low degrees of <sup>oxyds and</sup> heat. He digested 2 ounces of spermaceti oil with one <sup>earths on</sup> drachm of white arsenic, in a heat of  $180^{\circ}$  of Fahrenheit, for six hours, and let it stand till next morning. The oil was then perfectly clear and colourless, and heavier than before. A great part of the arsenic, however, remained undissolved at the bottom of the digesting vessel. Thick train oil was digested with one drachm and a half of white arsenic. No great alteration was observed in the colour; but it was clearer and more limpid. As a considerable portion of arsenic was dissolved, he wished to precipitate it so as to leave the oils pure and colourless; and on putting a few drops of vitriolic acid to portions of them, the arsenic was deposited, leaving the oil, particularly the spermaceti oil, as pure and colourless as before. Nitrous acid changed the train oil to a dark brown.

Three ounces of spermaceti oil were digested with one drachm of litharge for six hours, at  $200^{\circ}$  of Fahrenheit; it became clearer, but not so colourless as when treated with arsenic; the litharge was changed to a white colour. Train oil was but little affected in low degrees of heat, but in higher became discoloured; vitriolic acid added,

precipitated the litharge from the spermaceti oil, and left it pure and clear, though not quite colourless. Nitrous acid changed them to a dark brown. Two ounces of spermaceti and half a drachm of red lead, digested eight hours, the oil was not changed; the heat being increased till nearly boiling, it became dark and discoloured. Train oil the same. White lead and the oxyds of copper formed on the distillation of acetated copper, had the same effect with the red lead; but less of the oxyds of copper appeared to be dissolved than of those of lead.

Two ounces of spermaceti oil and one drachm of earth of alum, precipitated from a solution of alum by potash, were placed three hours in a sand heat from  $180^{\circ}$  to  $190^{\circ}$ . The oil became clear and colourless, the gluten having fallen with the earth. Train oil was likewise rendered much purer by the same means, but not equal to it. Aerated and pure magnesia precipitated the mucilage whilst warm; but on cooling, the mucilage and magnesia rose and mixed again with the oils. Two grains of pure lime, added to one ounce of each, turned them thick and dark coloured in the cold. In the experiments with the earths, not the smallest particle seemed to be dissolved, as on the addition of any of the acids, they instantly changed to a very dark colour. It appears, that the metallic oxyd gives up it's oxygen to the oil, while the mucilage of the oil unites to the metal; hence, probably, in high coloured oils, the superabundant carbon unites with the part of the oxygen of the calx, and forms carbonic acid, and divests the oil of it's colour, whilst the oxyd attracting the mucilage, may contribute to the same end. Yet it is very remarkable, that an earthy substance or alumine, which is not known to contain either oxygenous or carbonic gas, should discolour oils more powerfully than most of the metallic oxyds, and equally with any of them. This earth has a strong attraction



for colouring matter, and on this property depends it's use in dying.

*Animal volatile oil.* The oils already mentioned, we have seen, are mild both in smell and taste, insoluble in water and alcohol, do not rise at a boiling heat, contain a large proportion of acid, and are already formed in the animal in a fixed state. In the distillation of animal substances, however, and particularly of the more gelatinous kinds, when pushed beyond the boiling point, there arises another oil from the union of it's component parts, which are disengaged by the heat, and which oil, from it's burnt smell, has been called an *empyreumatic* oil; it comes over with a quantity of volatile alkali, is more or less dark coloured according to the quantity of carbon it contains, and from being at first fluid, becomes thicker and deeper coloured as the heat is increased, until it is of the consistence of tar. According to Spielman, the animal is sharper, according to Machy, richer in ammonia, than the vegetable empyreumatic oil. This oil, when rectified by distillation, and in it's pure state, is quite colourless, and it is called, from it's volatility, *animal volatile oil*, or *oleum animale Dippelii*; and possesses many different properties from the fixed oils before mentioned.

Animal volatile oil.

Its properties different from the fixed oils.

It has a strong penetrating aromatic smell, a strong sharp taste, but by far not so disgusting as the empyreumatic oil; it is perfectly transparent, and, after æther, the lightest of all fluids, since a flask that contains half an ounce and six grains of the best æther only holds half an ounce and fifteen grains of this oil; it is likewise nearly as thin and volatile.

It is in part soluble in water, and by repeated agitation with it, changes the syrup of violets green, arising, according to Parmentier, from it's ammonia.

With the vitriolic acid it forms, according to Achard,

an acid soap, and it separates it from the muriatic acid in that state.

Muriatic acid dissolved it at the boiling point, and it became black and thick; with four parts of this acid there was even an incipient solution in the cold, and the mixture became brown.

Diluted nitrous acid, according to Leonhardi, produced a purple colour with it, but at the boiling point, converted it into a dark blue, foaming, thick mass: with smoking nitrous acid it inflames, and when concentrated, takes it from the muriatic acid, and forms with it a black resin.

The acetous acid dissolves it.

Crell obtained a soap with the vegetable, and the oil from suet; and Schulze observed, that an aqueous solution of the alkaline soap, made by long trituration with Dippel's oil and tartar, precipitated Prussian blue from a solution of vitriol of iron. Alkalis also separate this oil from the muriatic acid in the state of soap.

It is dissolved by spirit of wine.

Exposed to the atmosphere, it becomes coloured, first yellowish, then brown, and loses its transparency.

It does not change the colour of litmus paper, or syrup of violets, so as to show the presence of an acid or alkali.

Hildebrandt thinks it differs from vegetable ethereal oils only by the phosphorus it contains. The properties of this animal volatile oil sufficiently show the difference between it and the other animal oils; but, according to Macquer, the most distinguishing character is, that all other animal and vegetable oils contain an acid, which appears on distillation, whilst this, on the contrary, appears to show something of a volatile alkaline nature. Pœrner, however, is of opinion, that although on the first appearance this oil may seem different from those of vegetables, yet it is the same oil which has undergone a

Opinions  
concerning  
the presence  
of an acid in  
it.

change from the difference of the body in which it resided ; for if animal and vegetable oils be pushed to their greatest state of fluidity, and are deprived of all foreign matter, no difference will be observed. To this may be added, as Leonhardi observes, that although a free acid or an alkali has not been proved to exist in this animal oil, either in it's empyreumatic or pure state, or in other empyreumatic oils, yet the presence of an united acid, or a basis capable of becoming so in them, may be concluded. 1st. From the resemblance to all other oils. 2d. From the change of colour to a brown, when this volatile oil is exposed to the atmosphere ; and Demachy found that when this oil was digested with caustic ammonia it remained colourless ; on the contrary, acids soon coloured it, from which it is supposed that it's brown or dark colour, when exposed to the air, arises from a disengaged acid, or from the addition of vital air, the acidifying principle. 3d. From the foliated matter obtained by Crell, on evaporating an aqueous solution of the sediment, produced from a mixture of empyreumatic oil, with the vitriolic and nitrous acid united, which perhaps might be the oxalic acid. 4th. From Dehnen's ammoniacal salt in crystals from spirit of hartshorn, and Schulze's experiment in the precipitation of Prussian blue, already related ; where the presence of phosphoric acid was supposed.

Although all animal substances afford this volatile oil by distillation, yet all of them are not made use of for that purpose. Those parts only are to be chosen which contain the purest gelatinous matter, and are free of all fat particles ; since they produce, at the same time, an acid which is separated with difficulty ; hence, to procure it in it's best state, neither the flesh, bones, nor even the blood of animals are chosen, but the different sorts of horns, particularly hartshorn, as they afford a large quantity of pure gelatin, which is the most productive of oil.

Substances  
the best to  
produce it.

Methods of  
preparing  
it.

With respect to the manner of preparing it, several methods have been recommended. It is found necessary at each distillation to change the vessels, or at least to cleanse those which have been used; as the least particle of the thicker and less volatile parts is sufficient to spoil a large quantity of the more volatile oil. According to *Model*, a quantity of empyreumatic oil of hartshorn is to be put into a clean retort, and having wrapped some well washed linnen round the mouth, it is to be subjected to the gentle heat of a sand bath: when a few ounces of pure oil are come over, which arises after the aqueous part, and a coloured oil is beginning to show itself, the receiver is to be changed; and the oil which first came over being again distilled, will be found pure and good. By this means as good an oil is obtained as that got by former chemists, after 50 or 60 distillations. A still better method, he found, was, to distil the first volatile portion, with four or five times it's quantity of distilled water; it is then clear and pure; he has even sometimes experienced, when the empyreumatic oil was not too thick, that by the addition of water, the volatile oil was obtained sufficiently pure, without undergoing a second operation. *Tibøl*, an apothecary at Groningen, recommends the empyreumatic oil of hartshorn to be mixed with three or four parts of warm water, and digested for 24 hours; it is then to be put into a retort, taking care not to let it touch the neck; a receiver is to be luted to it, and the day after, it is to be distilled by a gentle heat in the sand bath: the first oil that comes is yellow, and mixed with a volatile alkaline fluid; the next is purer, and the last black and thick. Hence the receiver is to be changed three times; the second oil is to be distilled again, and the purest part to be rectified with an equal quantity of water. *Dehne* is said to have improved the method of *Model*, by advising to make use of a cucurbit in the distillation of the pure oil

*Model*.

*Tibøl*.

*Dehne*.



from the oil of hartshorn, as the difficult cleansing of the neck of the retort may be dispensed with; and when the alembic becomes discoloured with yellow oil, it may always be replaced by another. In this manner, from rectifying the yellow and red oils, got from two pounds of oil of hartshorn, which arise after the white, together with the last, he obtained rather more than 514 ounces of beautiful pure Dippel's oil. Previous, however, to this chemist, Schulze had already mentioned the use of a cucurbit with it's alembic in this process, in which, to spare the repeated rectification, he advises to extract the oil from unquenched lime; but as the heat arising from the lime might change the white transparency of the oil, as Crell found heat to have this effect, it is better let alone. Although the name of Dippel has been given to this volatile animal oil, he was not the first chemist who discovered it, as Van Helmont had already mentioned it in his *Aurora Medicinæ*; and Homberg, it appears, had likewise prepared it from the human excrement; and according to Schulze, Count Wittgenstein had obtained it from the same substance, at Berlin, in the highest rectified state.

As this oil is very much inclined to lose it's whiteness and become less fluid by only exposing it a short time to the atmospheric air, from the evaporation of it's more volatile parts, and the dark colour which the remaining less volatile oil receives, it is necessary, in order to preserve it pure, to put it in small vials as soon as it is prepared, provided with ground stoppers, over which caps of bladder or lead are tied. Deyne advises a few drops of distilled water to be previously poured upon the top of the oil.

This oil has been used in medicine: it was recommended by Dippel, to be given a few hours before the attack of the paroxysm of a fever, in a dose of between

Method of  
preserving  
it.

Recom-  
mended by  
Dippel in  
fevers.



And by  
other physi-  
cians.

thirty and forty drops, and it was said to procure sleep, and prevent another paroxysm. It has likewise been used by, and mentioned in the writings of Frederic Hoffmann, Junker, Boerhaave, Vater, Haller and Lober, Machard and Reinhard, Ludolf, Hartmann, Foxe, Baumer, Parmentier, and others, who have recommended it in various diseases, and attributed very great effects to it. It is prepared according to the prescription of the last London Pharmacopœia, by distilling one pound of the oil of hartshorn three times, by the name of *oleum animale*.

The component parts of oils are hydrogen, carbon, oxygen, and phosphorus; but from the want of azot, they are not looked upon as perfectly animalized.

As there have been various opinions respecting the uses of oil in the animal body, different hypotheses have been invented of it's formation.

Opinion of  
the forma-  
tion of oil in  
the animal  
body.

Both the uses and formation of it are, however, obscure. With respect to it's formation, one of the most probable theses is that of Dr. Beddoes, which, although it explains many facts hitherto inexplicable, is subject to many exceptions. The foundation on which it rests is, that whenever there is a certain diminution of oxygen in the animal system, fat will be produced. The following observations, according to Coindet, seem to support this assertion. The chemical analysis of fat shows, that six parts of it contain nearly five of carbon, and one of hydrogen, and some sebatic acid. The fat parts of animals only differ from the fleshy, in the last containing azot and more oxygen. By this means the change of muscles into a substance like spermaceti in the churchyard of the Innocents at Paris has been explained by Fourcroy, and it has been observed, that fat in the living body increases at the expense of the muscles, and vice versa.

The want of oxygen, considered as a cause of corpulency, is indicated by the analogy which exists between

obesity and the sea scurvy, which seems only to be owing to a gradual abstraction of a part of the oxygen in the system. The sea scurvy is never announced by meagerness, for a fullness of the habit is the first symptom of the disease. Dr. Trotter observes, that when a negro becomes rapidly corpulent, he never fails to be attacked by the scurvy, from which, according to the comparison of Dr. Beddoes, it appears, that corpulency is to the scurvy what cachexy is to dropsy. According to Saussure and Humbolds, the atmosphere of high mountains contain less oxygen than that of lower regions, which explains why Condamine was attacked by scorbutic symptoms on the summit of Pinchina. All the symptoms of scurvy prove likewise that it arises from a privation of oxygen: thus the surface of the body is covered with livid spots, the arterial blood is very little fluid; and after death, the left auricle is filled with venous blood; which Dr. Goodwin found in animals that had been deprived of life for want of oxygen. Dr. Lind informs us, that when death has been sudden, and no effusion is found in the cavities of the body, the auricles and ventricles are filled with blood, and especially the left side of the heart, which is the more remarkable, since that side rarely contains much blood after death.

Country people know from experience, that to fatten poultry, they must be kept in darkness; that substances proper for prolonging their sleep must be mixed with their food, as tares, or spirituous liquors. It is a curious circumstance, that the age when the secretion of fat is most considerable is about the 40th year, a time when the arterial system ceases to act such a conspicuous part in the animal economy: either, as Dr. Coindet thinks, it is then ossified, or in part obliterated, while the venous system coming more and more into action, acquires that influence so considerable in old age. Perhaps the arte-

ries, the action of which is then visibly diminished, furnish the system with less oxygen at that period, which may be looked upon as the cause of the corpulency of middle aged people.

It may be objected, that children, whose venous system is not yet developed, have, however, a remarkable plumpness. But this difficulty has been resolved in the following manner: The venous blood, when it arrives at the lungs, undergoes changes that are well known; and it may happen, that as respiration is more or less perfect, the blood may lose a greater or less quantity of carbon or hydrogen. In proportion as it loses less, the secretion of the fat will be more abundant, which affords an explanation of the enormous quantity of fat in amphibious animals, and fish, whose respiration is imperfect. They retain, therefore, more hydrogen and carbon, which passing into the arteries, Dr. Coindet thinks, occasion that considerable secretion of fat, and probably produce that voluminous size of liver, found in fishes, in which the circulation is such, that almost the whole blood goes to the liver, either to operate there a secretion of fat, or of bile, the constituent parts of which do not differ much from those of the former. The same reason may be given why children, who do not respire in the womb, have a full habit of body until the third or fourth year, for the foramen ovale is not obliterated until that period. This seems to be confirmed by the observations quoted in the medical transactions of London, and by those of professor Sandifort, of Leyden, which give an account of individuals remarkable for their corpulency, in whom it was found on dissection, that the foramen ovale was not closed up, from which it appears, that the greater part of the venous blood passed directly from the right into the left ventricle, to be transmitted to the aorta, and thence to circulate through the whole system, without having undergone

any of those changes which blood undergoes in the process of respiration. Their lungs were diminished in size, and in a collapsed state, which indicated they had not discharged all the functions of respiratory organs; hence the enormous size of the liver in the fetus, and the reason why diseases of the liver, such as scirrhus tumours, &c. are incident to people who are more or less corpulent. The blood of plethoric, or of fat people, is also commonly of a darker colour, and more viscous than that of lean people, which last is generally very fluid. Those who drink cider are more meager than those accustomed to beer, porter, or other liquors of the same kind. In Holland, and in some parts of England, the inhabitants are very corpulent, whilst in France they are thin, from the same causes.

The facts and observations already made on the formation of oil, are sufficient to inform the reader, that future experiments are necessary to render it complete.

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## ACIDS.

ANIMAL ACIDS had been so little investigated at the time of Macquer, that he informs us in his dictionary, it was not perfectly ascertained whether they were essentially different from those of vegetables. That they differed from the mineral acids, was granted; and it was thought probable, in the same manner as the vegetable acids differed from them, viz. by a portion of oil which they appeared to possess. He has only mentioned three of these acids, *that of fat, of ants, and the phosphoric acid.* A very few years afterward, a great addition was made to this class; for we find that Morveau in the *Encyclopédie Méthodique* has reckoned six acids in the animal kingdom, viz. the *phosphoric, prussic, formic, sebatic, galactic, and saccharo-galactic, or lactatic.* To these he afterward added three more, the *lithic, the bombic, and the gastric.* It appears, that the weakness of some of these acids was attributed to the oil, which was supposed to enter their composition; and this chemist proposes to examine the truth of it's being an essential part, and surmises, that perhaps it may be separated from them in the same manner as the colouring extractive matter is separated from the acetous acid; this being done, he thinks they would become more strong, and perhaps resemble some of the acids already known; and that it is very probable that the acids procured from all fat substances might be so purified, as to be identic with the sebatic acid.

Their number, according to Macquer.

Morveau.

Ker, who published his dictionary in 1789, nearly three years after the work of Morveau appeared, but had no opportunity of consulting it, has treated as animal, *the acids of ants, and some other insects, of fat, of milk, perlated acid, the phosphoric, and the acids of Prussian blue, and of sugar*

of milk. This chemist was of opinion, that these acids had been so little investigated, as not to make it certain whether they were essentially different from those obtained from vegetables; “but we are certain,” says he, “that they differ in the same circumstances as the vegetable acids do from mineral acids; and probably, this difference proceeds from the same cause, which constitutes the difference betwixt the vegetable and mineral acids, viz. the combination of oily particles with the former.”

When the nature of these, as well as acids in general, were better understood by a further investigation of their properties and component parts; the French chemists, and more particularly Lavoisier, made a new division of them, according to their component parts; hence Fourcroy in his *Philosophic Chimique* has placed the animal acid in the fourth class of acids, having their radicals composed of three bases, at least, viz. of carbon, hydrogen, and azot, which united to oxygen, in various proportions, form the peculiar acid; and these he calls acids with ternary radicals; to which Lavoisier had added phosphorus, but not as an essential part. They are the least known of all the acids, but have some properties, which may be considered as classic characters; such are the properties of affording ammonia on decomposition by fire, and of giving the prussic acid by a change in the proportion of their principles.

According to Fourcroy, the prussic acid appears, to this class of acids in general, what the oxalic is to the vegetable acids; to which may be added, that on converting animal substances into oxalic acid, by the action of the nitric acid, prussic acid is constantly formed during the action, which is disengaged in the form of vapours. This chemist has distinguished seven animal acids, viz. *the lactic, saccho-lactic, sebacic, lithic, formic, boracic, and Prussic*. From the diversity of opinions, respecting which are

or are not to be ranked as animal acids, it is evident, that principles are still wanting upon which their distinguishing characters are to be founded : and if, in the formation of this class, all those acids are to be excluded, which are not solely procured from the animal kingdom, several acids will be refused admission, which to all appearance are of animal origin.

With respect to the phosphoric acid, the illustrious *Phosphoric* Bergmann considered it as belonging to all the kingdoms. Morveau, however, is of opinion, that although we have no direct proofs, there is some reason to believe, that it belongs exclusively to the animal. He suspects that it is only carried accidentally to the mineral and vegetable parts of the creation, with the other wrecks of animated bodies, and that it is preserved only by reason of it's fixity, or on account of that indestructibility which is known to be one of it's principles. " If," says he, " this acid is found without having undergone any alteration amongst osseous matter, which has been inhumed for ages, as Berniard has proved from the analysis of a piece of the *montagne aux os* of Gailenruth, in the margravate of Bayreuth ; it is evident, that the most powerful agents of decomposition, the most energetic mineral menstrea, cannot even by the aid of time resolve it's radical principle into it's elements, and are confined to depriving it of it's basis only under certain circumstances." He however confesses, that this hypothesis has no other foundation than the great proportion of phosphoric acid which all animal matters afford, and which living animals daily furnish in their excrements, and the quantity compared to that which may be supposed to exist in their aliments.

The sebacic acid is common to both vegetable and animal oils. *Sebacic*.

The zoonic acid, first discovered by Berthollet, in the *Zoonic*

distillation of animal substances, is likewise found in some vegetable matters, on submitting them to the same process, as in the gluten of flour, yeast, &c.

Oxalic and  
malic.

There are other acids which have likewise been extracted from animal substances, which have not only a less title to being called animal, but which evidently do not belong to them. Thus Berthollet has been able, by the means of nitrous acid, to extract the oxalic acid from several animal substances; and Scheele discovered the malic acid, and it appears, that these two acids generally accompany each other. It is necessary, however, that the nitrous acid be concentrated. Scheele poured two parts of fuming nitrous acid upon one part of glue, and placed the mixture on a sand bath, the glue was soon dissolved, emitting deep red vapours. The next day, he found a number of crystals of the oxalic acid, which had been formed on the solution becoming cool, and the rest of the liquor which refused to crystallize, being saturated with chalk, the malic acid was easily disengaged from it. Linglafs, white and yolk of the egg, and blood treated in the same manner, afford the same products. There are three important observations to be made on these decompositions of animal matters. 1st. A fat thick substance is always separated. 2d. If the gas be collected, which arises during the operation, a little carbonic acid is found in it; a good deal of azot gas, and a small quantity of nitrous gas; it is more particularly with the yolk of the egg that these phenomena are the most sensible. Scheele did not find the azot gas (air phlogistique) when he procured the oxalic acid from vegetable substances. 3d. Every time the oxalic acid is prepared, there passes into the receiver, after the nitrous gas, a small portion of acetic acid. Crell observes, that this fact had been made known by Scheele and Westrumb nearly at the same



time, and before they could know each other's discovery.

Scheele having submitted to the same operation what <sup>Benzoic.</sup> Rouelle has very well named, the *saponaceous extract of urine*, which is obtained as before related, by evaporating it to the consistence of honey, and having then digested it in spirit of wine, to separate the greatest part of it's salts, and evaporated the spirituous solution, which leaves a saponaceous extract equally soluble in water or alcohol, found, that this matter afforded no oxalic, but some *benzoic acid*, which was in a state of a benzoat of ammonia. This acid does not appear to be formed during the operation with the nitrous acid, because it is only necessary to dissolve this urinous extract in a little water, and add to it some vitriolic or muriatic acid, in order for the liquor to become immediately turbid by the precipitation of the concrete benzoic acid. The celebrated Rouelle had well observed, that this saponaceous extract contained a good deal of volatile alkali, but he did not know the acid to which it was united.

The benzoic acid is also procured by distillation from the saccholactic acid; and the consequence which Scheele draws from it is, that it undergoes no alteration in the circulation of the blood. This supports the idea of Morveau, that vegetable acids may pass into the animal kingdom without losing the characters that disclose their origin. The chemist ought not to neglect to follow these acids into these emigrations, because it is only by such means that the system of their properties can be completed, their analysis rendered exact, and a solid basis prepared for physiological investigation. To these may be added the acetous acid, which is observed to be produced from the spontaneous fermentation of broths. <sup>Acetous.</sup>

Having thus given a short account of the acids that are found in vegetables, as well as in animals, it may be ob-



served, that those acids which are purely of animal origin are few in number, six being perhaps the utmost, and are the following, *formic*, *lactic*, *saccholarctic*, *bombic*, *lithic*, and *amniotic*; they are said by Fourcroy, as before observed, to be characterized by affording ammonia and the prussic acid by heat. As, however, the *phosphoric*, *sebacic*, and *zeonic* acids, may be supposed to derive their origin from those parts of vegetables which may be looked upon as animalized in a greater or less degree, it has been thought proper to admit them in the present article of animal acids, till future investigation shall determine to what class they really belong. With respect to the prussic acid, as it is evidently an artificial acid, it has been left out. The number of acids therefore which are supposed to derive their origin and characters from the process of animalization may be extended to nine.

Other acids  
suspected in  
the animal  
kingdom.

Besides these, the animal kingdom is supposed to afford others, particularly amongst insects, but which have not as yet undergone any chemical investigation; and it is suspected, that the generality, if not all of them, are capable of affording an acid liquor, which they contain in a disengaged state.

Thus, it has been long ago observed by Hooke, that insects of the hymenoptera class, which are furnished with stings, such as bees, wasps, hornets, are also provided with an acid liquor, which they discharge on being irritated, in their own defence. Some of the class diptera, as the moschetto and the small gnat, have been observed, on flying into the mouth, to impress a manifest acidity on the organs of taste; and Fourcroy has often observed, that the buprestis and staphilinids of the coleoptera class reddened the blue paper of such boxes as they were confined in. Chauffier has drawn an acid from the grasshopper, the red bug, the lampyris, and several other insects, by means of digestion in alcohol. Lister indi-

tates a species of millepedes (Collect. acad. T. 2. p. 303.) which contains an acid. Leonhardi informs us, that an acid may be extracted from the locust by alcohol, whilst Dehne found one in the meloe proscarabæus and maialis; (Crell's N. Ent. xiii. 166 f.) and Bonnet has observed, (Savans estrang. T. 2. p. 276.) that the liquor spurted by the great caterpillar of the willow in it's own defence is an acid, and very active in it's effects, by occasioning a sense of burning; that it is perfectly clear and colourless, and smells and tastes like concentrated vinegar, to which Bergmann compares it; that it coagulates blood, deposits a coagulable lymph in alcohol, and reddens the blue paper of litmus; but, however, from it's great volatility is soon dissipated.

*Formic acid.*—There can be no doubt that the strong <sup>Formic acid.</sup> acid smell which is observed to arise from the atmosphere of an ant-bed, after being disturbed, must have been known to the ancients, but from their want of chemical <sup>It's history.</sup> knowledge, it is not very extraordinary they should have been ignorant of it's being owing to a peculiar acid. According to Morveau, it was not till nearly the end of the 15th century, that some botanists observed, with surprise, that the blue colour of the flower of the cichory, when cast into a heap of ants, *became as red as blood.* Mention of this fact is made in the works of Langham, Hieronimus Tragus, Othon Bransfeld, and John Bauhin.

In 1688, Hunerwolf published an account, in the Ephemerides of Germany, of a fuller having been cured of a head-ach, to which he had long been subject, as he was standing over an ant-bed, in order to procure some of the insects; and that his hands had been exco-riated by the acid liquor they emitted.

This acid liquor, however, was not thoroughly established <sup>Fisher.</sup> as an acid, and procured in a liquid form, until Samuel Fisher

obtained some on treating animal substances by distillation; he tried it's action on lead and iron, and communicated his observations to John Wray, who inserted them in the Philosophical Transactions for the year 1670; which distillation has since been described by Etmuller in his works on pharmacy.

Hoffmann. Hoffmann afterwards extracted spirit of wine from these insects, and called the product he obtained, in the alchemical style, *water of magnanimity*.

The existence of this acid was also proved by Sperling, Homberg, and Casper Neumann; and numerous experiments were likewise made upon it by the celebrated Margraaf; but for the best dissertation on this subject we are indebted to Arvidson and Oehrn.

Margraaf. Margraaf examined it in 1749, and it is from his experiments that Macquer has compiled the article of this acid in his excellent dictionary. Margraaf found, that when these animals were shaken, either in water or spirit of wine, they communicated an acid taste; that this acid is so volatile as to arise with the alcohol in distillation; but that the greater part is sufficiently fixed to remain united with the remaining phlegm; that all the acid may be obtained from these insects, on submitting the water charged with them to distillation in a water bath. Margraaf obtained 11 oz. 2 drachms of acid spirit from twenty-four ounces of fresh ants without any addition. He found that this acid had the principal properties of other acids, that it formed deliquescent crystals with fixed alkalis, which exposed to a great heat gave two fluids, the one scarcely acid, and the other urinous or alkaline; whilst the remainder, dissolved in water and evaporated, afforded large crystals, which had all the properties of fixed alkalis. If, however, the vitriolic acid be poured on these alkaline crystals, white vapours arise, although no acid is procured by distillation. From these white

vapours, and the ease with which this salt crystallizes, Margraaf conjectured the presence of a concealed acid. With the volatile alkali it formed an ammoniacal fluid, which was equally as uncrystallizable, as if vinegar had been used instead of this acid. It formed crystallizable salts, however, with unquenched lime, chalk, and coral.

With respect to metals, Margraaf found that it had but little or no action on silver, lead, tin, and antimony, somewhat more on copper; whilst it showed a very strong menstrual power on iron and zinc. It likewise dissolved the calces of silver, copper, lime, and lead; but had no effect on those of mercury, bismuth, and antimony. It vitrifies the calx of mercury.

From this acid not precipitating silver, lead, or quicksilver, from their solutions in nitrous acid, this chemist affirms it has no similarity with the muriatic acid, and from its not taking lime from the muriatic acid, that it does not agree with the vitriolic; but concludes from the above experiments, with which Macquer coincides, that it has many, but not all the properties of vinegar.

In the year 1770, that most excellent chemist Rouelle, Rouelle, having previously confirmed the above facts by experiments, exposed them in his lectures to the students in the king's garden. We are told, by Macquer, that he had obtained the same products from these insects as Margraaf, with a small difference in the quantity of oil obtained by distillation.

In 1777 Arvidson and Oehrn endeavoured to complete Arvidson  
and Oehrn. our knowledge of this acid in an excellent dissertation, which they published at Leipzig, and which has principally served Morveau for his account of it in the *Encyclopédie Méthodique*.

It appears from these two chemists, that all species of ants are not equally good for the extraction of this acid. Thus, the small red ant, commonly found in gardens,



The species  
that affords  
it in the  
largest  
quantity.

affords very little of it; the same may be said of those species called by Linnæus, *herculanea*, *fusca*, *cespetum*: the species which supplies it in the greatest quantity is of a reddish colour, and of a middle size, called by Linnæus, *formica rufa*; it generally inhabits the woods, but is sometimes found in gardens and in fields near cities, more particularly in places that are a little elevated and dry.

Season for  
procuring  
them.

Every season is not proper for their collection; they contain the most acid during the months of June and July; at this time it is only sufficient to press one of these ants on a piece of paper coloured blue by litmus, to give it the most lively red colour: they will sometimes even leave spots of this colour by simply marching over it; when this happens, it is a proof that the species and the season cannot be better chosen.

Method of  
collecting  
the ants.

In order to collect them, small sticks must be placed over the ant bed after it has been opened; and when the ants have attached themselves to this, they are to be shaken off into a large earthen vessel filled with water, until it is so full as not to be able to destroy any more; they are then to be cleansed of all foreign matter, and gently dried; they are then fit for use.

Two ways  
of extract-  
ing the acid.  
1. By dis-  
tillation.

To extract the acid from these ants there are two methods, viz. by *distillation*, and by *lixivation*. With respect to the first, a glass retort is to be filled half full of them, a receiver affixed, a gentle heat is to be applied, and augmented by degrees, until all the acid has passed over. In the receiver the formic acid is found, which is very acid in a liquid state, with a little empyreumatic oil on it's surface, which must be separated by means of a strainer previously steeped in water. In this manner Arvidson and Oehrn extracted seven ounces and half of acid from one pound of ants, the specific gravity of which, at a temperature of  $15^{\circ}$  above zero, was to that of water



as 1,0075 to 1,0000. Morveau informs us, that he obtained from 49 ounces of ants, 23 ounces 2 drachms of a pretty strong acid. Some pour a little water into the retort, but this only serves to weaken the acid.

These chemists have found another way of procuring this acid, which is less embarrassing: the ants are first to be washed with cold water, they are then to be extended upon a clean linen, and boiling water poured on them; when the water becomes cool, fresh boiling water is to be poured on them, and repeated a third time, or until all the acid is extracted; the linen is then to be strained, and the water, to be collected and filtered.

By this means, from one pound of ants, about one pint of formic acid was obtained, as strong as vinegar, and the specific gravity of which was greater. These chemists are of opinion, that this acid might supply the place of vinegar for economical purposes. If it is to be kept, it must be deprived of it's oil, which the filter cannot completely separate, a part of which is fat oil, and the other part essential oil, which renders it turbid and disposes it to putrefaction; hence they advise it to be boiled several times, and with precaution, and thus purified they esteem it preferable to vinegar.

For chemical experiments, however, it is necessary to rectify this acid, which is done by repeated distillations by a gentle heat, in vessels somewhat elevated, until no more oil remains, *i. e.* until it becomes colourless, it being impossible entirely to deprive it of both these oils: for it appears, that even after four rectifications, the fat oil was still evident by an empyreumatic odour, and the essential oil by the zones that were formed. This empyreumatic odour flies off on exposure to the air; or still better by concentration from freezing; but as to the essential oil, it appears to be a constituent part of the acid, and is inseparable. The specific gravity of the acid thus

2. By lixiviation. rectified they found to be as 1,0011. The other process to obtain the acid is that of Thouvenel, by lixiviation, which he looks upon as the most easy. It consists in placing linen cloths impregnated with fixed alkali upon the ant beds, and the salt afterwards is to be extracted by lixiviation; but this process, it is observed, can only be of advantage when the acid is wanted to form a neutral salt with an alkaline basis.

Hermstadt does not approve of the method either of Margraaf or Arvidson of obtaining the formic acid; for in the one case the acid is in part destroyed by the fire, in part rendered impure by the decomposed oil; but in the other case it is too much weakened by dilution with water. He procured it much purer by expressing it from two pounds of dry living ants, from which he obtained twenty-one ounces and a quarter of a brown mucous acid juice. It had an acid aroma by no means unpleasant, and penetrating like the vapour of the acid of fluor. In taste, it resembled more the acid of tartar than vinegar.

From this he obtained by distillation, six ounces and half of pure formic acid.

From the experiments and observations of Arvidson and Oehrn, it appears, that the formic acid has the following properties.

Properties  
of the for-  
mic acid.

The specific gravity, when well rectified, is to water as 1,0453 to 1,0000.

It affects the eyes and the nose in a peculiar manner; it's smell is penetrating, but not unpleasant; it's flavour sharp and burning, and when diluted with water is agreeably acid.

It retains water so greedily as not to be entirely separated from it by distillation.

It reddens the blue colours of vegetables; it even changes the blue paper which encloses sugarloaves, and converts it insensibly to a yellow red. One part of this

concentrated acid mixed with 75 of distilled water, still reddens, although weakly, the syrup of violets; diluted with 430 parts of water, it produces reddish spots on paper coloured by the infusion of litmus; and with 1300 parts it produces effects only on the infusion of litmus. It readily unites with other acids.

Mixed with the vitriolic acid, it blackens it, and on becoming warm there arises white penetrating vapours; on boiling, an elastic gas is extricated, which unites difficultly with distilled water and lime water. On distilling this mixture, the formic acid is again obtained in small quantity.

Boiled with the nitrous acid, there arises phlogistic vapours, and a species of gas very little miscible with water, and which renders lime water turbid.

In this operation the formic acid is destroyed, and is not again obtained by distillation, especially if a large quantity of very concentrated nitrous acid has been used.

Heated by itself, it affords elastic vapours, which conducted through a cold earthen tube, afforded fixed and phlogisticated airs; through a red hot tube, inflammable air likewise. (Aichard, in *Crell's Annalen*, b. 1. f. 527 f. Fontana looked upon it as fixed air, *Rosier's Journal de Physique*, 1778) but it's being decomposable by the fire into fixed and inflammable airs (Bergman, *Opusc.* iii. p. 378) proves this not to be the case.

The muriatic acid does not change the formic, from which it is separated without loss by distillation. This, however, is not the case with the dephlogisticated muriatic acid; for it decomposes the formic acid in close vessels, and takes away it's phlogiston (according to the new theory, the formic acid seizes on the oxygen of the dephlogisticated muriatic acid) and decomposes it.

The formic acid appears not to be susceptible of forming an immediate connection with phlogiston.

By the aid of heat it attacks the foot of the chimney, becomes of a yellowish colour, and on cooling, lets fall a brown sediment; if this sediment be distilled, there comes over a liquor of a yellowish colour, of a disagreeable odour, accompanied by elastic vapours. Nothing of the kind is observed when this acid is boiled with powdered charcoal.

It unites difficultly with fat and essential oils; for the acid extracted from these unions after digestion, or by distillation, has not undergone any change of colour, although impregnated with the odour of these oils, and after evaporation it leaves marks of a residuum; it, however, completely dissolves the empyreumatic oil of the ants.

It does not unite with vitriolic æther.

It unites perfectly with rectified spirit of wine, and distilled, it afforded a formic æther, which burned with a white flame, without smoke or residuum. Buckholz obtained a much finer æther by procuring the acid from a formiat of potash. He first procured the formic acid by infusion, rectified and saturated it with purified potash, then extracted it to dryness, levigated it in a warm mortar, added half its quantity of smoking vitriolic acid, and obtained by distillation a strong pellucid formic acid; to this acid he added an equal quantity of pure alcohol, and by submitting the mixture to a gentle heat, he obtained a spirit of the odour of bitter almonds, which, being united with about one fourth part of distilled water in the receiver, afforded a real formic æther. (*Vide* Crell's N. Entd. vi. f. 55 ft.)

According to the experiments of Arvidson and Oehrn, the lee of potash exactly saturated with formic acid had a very saline and bitter flavour, but was incapable of being crystallized or perfectly exsiccated. After exposure to a strong heat, it became a dark green alkaline lump,



which united readily with water, and after a gradual evaporation before the sun, some little of the acid dropped from it; there appeared some crystallized scales, of scarcely any flavour; by which it resembled *terra foliata tartari*, acetated mineral alkali, as well as by it's deliquescing in the air, and it's solubility in alcohol; by distillation it afforded no acid. This formiat of potash is decomposed by barytes, which lays hold of it's acid; and by all acids which seize upon it's alkali, except the sedative salt, vinegar, the phlogificated vitriolic and nitrous acids, and fixed air.

With soda it formed foliated humid crystals, of a bitter saline flavour, soluble in twice their quantity of water.

With caustic volatile alkali, it afforded thin crystals, which appeared to be supersaturated with the acid from their reddening blue paper; they deliquesced in the open air. On distillation they afforded no acid or sublimate, but an alkaline fluid, and there remained a dark brown mass.

United with lime it forms a pellucid cubic salt, rather distorted, not deliquescent, as had been previously observed by Margraaf; efflorescent, soluble in eight parts of water, insoluble in alcohol, and of a bitter flavour. It gives blue paper a darker colour, affords no acid by distillation, decrepitates on red hot coals, and becomes darker; it is decomposed by barytes.

Equal parts of uncalcined magnesia formed with this acid a ley, from which some parts which were difficultly soluble fell down, afterward there appeared a transparent salt composed of spherical, aggregated, hairyform crystals, of little or no flavour, soluble in 13 parts of water, but not in alcohol; lime decomposed it. According to Bergmann (op. 1. p. 389.) it decrepitates in the fire. It is called by Bergmann *magnesia formicata*.

With barytes it formed clusters of crystals, needle shap-



ed, which were bitter; not deliquescent; soluble in four parts of water; insoluble in alcohol; became of a dark brown colour on burning, producing a smell of burnt sugar; and on exposure to a red heat, a coal which effervesced strongly with acids.

With the purest clay, or the dried earth of alum, it united with great difficulty, and scarcely to saturation. The solution is somewhat sharp and astringent.

The formic acid has no action upon siliceous earth.

It does not affect either platina, or gold, or quicksilver.

It converts copper into a light green calx. It formed with it's calx a beautiful blue solution, from which blue cubic crystals arose, of the nauseous flavour of verdegriſe; becoming white by efflorescence in the air; soluble in seven parts of water; burning with a green flame; not decomposed on distillation; decomposable by all the acids, except vinegar and sedative salt, as well as by lime, manganese, iron, lead, regulus of cobalt, and tin.

It dissolves iron with a strong effervescence, producing inflammable gas. The solution deposits ochre, and affords sometimes reddish yellow threadlike crystals, of an astringent flavour, easily soluble in water, dissolving difficultly in alcohol; which abandon the acid, with depositing black particles in water, and are decomposed by all acids, as well as by zinc and manganese.

It dissolves zinc likewise with a strong effervescence, producing inflammable gas. The clear, moderately astringent solution affords clear crystals, growing together, sometimes cubiform, insoluble in alcohol, difficultly soluble in water, which swell and become milk white on burning, melt with a penetrating smoke, afford ashes, and are decomposed neither by vinegar nor by metals.

It calcined, but scarcely dissolved, bismuth. From the sparing solution arose crystals that were soluble in water, became black on exposure to fire, and were decomposed.

ed by all acids, except vinegar, and by all metals, except silver, in the moist way.

By the assistance of heat it has some little soluble power on lead, and produces glasslike crystals.

It can only be united to tin and it's calces by digestion and a boiling heat. Part of it is in the form of a white calcined powder, and part a jelly difficult to be exsiccated. The powder is insoluble both in water and in alcohol, and burns first to a black, then to a white colour, afterward it flies off. The gelatinous flakes are precipitated by alcohol in the state of a pulverized calx. Vinegar produces no precipitation, but all acids which dissolve tin decompose it; lead produces the same effect.

It has no effect on antimony, arsenic, cobalt, and nickel, in their metallic state; it however acts upon their calces. By digestion with the calx of cobalt, precipitated by an alkali, it produced a pale purple solution, from which arose red coloured, irregular crystals; that were insoluble in alcohol, difficultly so in water, but were easily taken up by acids, and formed a sympathetic ink; they were decomposed by tin.

Digested and boiled with the calx of nickel, precipitated by an alkali, it formed a clear green solution, from which arose green threadlike crystals, aggregated in semi-globular forms, of difficult solution, which on distillation became yellow. They were neither decomposed by bismuth nor vinegar.

With the calx of manganese precipitated by alkali from it's nitrous solution, it easily formed a solution with effervescence; the crystals arising from it were coloured and soluble in 15 parts of water, but insoluble in alcohol, they had very little flavour and no action on the colour of the tincture of litmus. Alkalies, earths, and zinc decomposed them, and seized the acid; whilst all the acids, except vinegar, laid hold of the metallic part.

With the calx of arsenic it produces granular crystallizations, which are difficultly soluble, according to Bergmann (Opusc. II. p. 296.)

It dissolves minium without the assistance of heat; the crystals arising from the solution are prismatic, larger than those from a solution of the metal in this acid, sweet and astringent to the taste, and soluble in 36 parts of distilled water; with other water they produce a milky appearance. They decrepitate in the fire, melt, become black, and of a disagreeable smell, but afford no acid by distillation, although this salt is supersaturated with acid, and reddens blue paper. It is decomposed by lime, manganese, and iron; and by all the acids, except vinegar, sedative salt, and fixed air.

It has no effect on calcined mercury, but with red precipitate produces some small needle-shaped crystals.

The calx of silver precipitated by an alkali is sparingly soluble in this acid, forming with it pellucid, cubic crystals, difficult to exsiccate, easily soluble in water, but insoluble in alcohol, swelling and becoming black in the fire, with a disagreeable smell, easily decomposed by the acids, particularly by the muriatic, scarcely so by the vitriolic, and insoluble in vinegar. This solution is rendered turbid by all the metals, but copper precipitates the silver the best.

It's affinities according to these two chemists.

**Arvidson** and **Oehrn** have determined it's affinities to be in the following order :

Barytes	Lead
Potash	Tin
Soda	Cobalt
Lime	Copper
Magnesia	Nickel
Ammonia	Bismuth
Zinc	Silver
Manganese	Alum
Iron	The essential oils and water.

This acid, although it may appear weak, has, according to these two chemists, the advantage of the acetous, boracic, vitriolic, fuming nitrous, and carbonic acids; on some occasions, it is even superior to the arsenical acid, from which it takes nickel and cobalt.

It could not have been supposed that a degree of heat incapable of destroying this acid is able to change this order of affinities; yet the boracic acid at the boiling heat disengages it, which from this circumstance becomes the differential term of the wet and dry way.

Bergman had placed the affinities of the formic acid in the following order: According to Bergman.

Moist way.	Calx of lead	Dry way.
	tin	
Barytes	copper	Barytes
Potash	bismuth	Potash
Soda	antimony	Soda
Ammonia	arsenic	Lime
Lime	mercury	Magnesia
Magnesia	silver	Metallic calces
Argile	gold	Ammonia
Calx of zinc	platina	Argile.
iron	water	
manganese	alcohol	
cobalt	phlogiston	
nickel		

It appears therefore that Bergman had placed in his table of chemical affinities arsenic after nickel, antimony after bismuth, and platina after silver; but Arvidson and Oehrn found that arsenic was not attacked by the formic acid, that its calx was only dissolved as in water; that this acid did not contract any union either with antimony or its calx; and that the small portion of the precipitate of platina, which this acid dissolved at first, was very soon

deposited, particularly by the aid of heat, in the form of a ferruginous powder.

*The formic mistaken for other acids.*

The formic  
mistaken for  
other acids.

Margraaf, and several other chemists who have examined the formic acid, looked upon it to have a great analogy to vinegar, “but,” exclaims Morveau, “what do they mean by this? that it has nearly the same degree of acidity; that it is susceptible of the same degree of concentration; that it is decomposed in the same manner by fire; that it can be substituted for it in economical or medicinal purposes, when only an acid of the same intensity is required? In these senses all substances are analogous to each other, for there is no one in nature, that is distinguished from *all* the others by *all* its properties.”

It differs from vinegar, 1st. by its specific gravity, for although it approaches vinegar very near in this respect, yet it is saturated by a smaller quantity of an alkali or an earth. 2d. By its effects with alkalis; since it forms with ammonia a deliquescent crystalline salt; with lime, one that forms irregular cubes, and with magnesia, a salt that is difficult of solution. 3d. By its metallic salts; for example, it forms with copper, not a dark green, but a blue cubic salt; with nickel, not a cubic but a clustered salt; and with zinc, one that is cubic and not scaly: it neither dissolves the calx of mercury nor of antimony, but vitrifies the former: finally, it dissolves the calx of iron, and likewise forms crystals with iron itself; which vinegar, according to Arvidson, does not. 4th. By its affinities, for it always detaches vinegar from its union, and even takes nickel and cobalt from the acid of arsenic.

According to Thouvenel, the formic acid is very analogous to the phosphoric, or, as he calls it, the microcosmic acid; but he has not given any account in which



properties this analogy consists. On comparing these two acids together, there is not perhaps two others which have so distant a resemblance. The first sustains a vitrifying heat, whilst the other is destroyed by the heat of distillation; the one forms with lime an insoluble salt; the other a salt that crystallizes and is soluble, &c.

Lifter affirmed that he had extracted a similar acid from wasps and bees; but Arvidson and Oehrn were not able to obtain it from these insects, and at present the ant is the only animal in which it has been found.

The formic acid is therefore an acid *sui generis*, differing in it's basis, but possessing the same acidifying principle as the others, viz. vital air. "There needs no other proof of this," says Morveau, "than the effervescence produced by the residuum of the distillation of formiat of potash. Margraaf, who observed this phenomenon the first, before the theory of gases was known, was astonished, with reason, at the disappearance of the acid of this salt; which had only left a salt with alkaline properties, and which effervesced with it's own acid. What passes in this operation is now known; if the acid be only weakly attached to it's basis, it is disengaged; if the union be more intimate, a stronger degree of heat is necessary, which destroys by it's violence the composition even of the acid; and the acidifying principle, the air being detached from it's bonds, is converted into carbonic acid gas, which uniting with the alkali, renders it effervescent."

According to Morveau, this acid contains phlogiston, which is less adherent to it than to vinegar, since this last readily dissolves the calx of mercury, whilst according to Arvidson and Oehrn the formic acid reduces it; *i. e.* is obliged to yield it's phlogiston to the more powerful affinity of the mercurial earth; it also yields it to the dephlogisticated muriatic acid.

These phenomena are better explained by the new chemistry.

Fourcroy's  
definition of  
t.

The definition which Fourcroy has given of the acid is the following :

“ The formic acid is extracted from ants either by distillation or expression with water ; reddens blue flowers in the living insects ; disengages itself from them in the form of a very strong odorous vapour, analogous in it's odour to that of musk ; destroys animals under this gaseous form ; is capable of serving economical purposes like vinegar ; is decomposed by a great heat ; takes oxygen from oxygenated muriatic acid ; is oftentimes stronger than sulphuric acid ; and forms salts with alkalies and earths, which are crystallizable and not deliquescent.”

Encyclopéd. Méthodique. Chémie. tom. 1. p. 1. artic. Acide Formicin, ou des Fourmis, p. 60.—Macquer's Chym. Wœrterbuch, von Leonhardi, tom. 1. p. 179. art. Ameisenfaure.—Margraaf's Chymische Schriften, Berlin. 1768.—Rouelle, in the Journal de Physique, Mars. 1773.—Abhandlung von der Ameisenfaure, von Herrn Arvidson and Oehrn in Baldinger's Neues Magazin für Aerzte. 2 b.—Philosophie Chimique par Fourcroy.—Bergman's Opuscul. iii. tab. 2. No. 20.

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#### LACTIC ACID.

Lactic acid.

ALTHOUGH the acidity of milk or whey, from the great ease with which they undergo the acetous fermentation, was known to the ancients, yet it was not discovered to be owing to a peculiar acid, until the experiments of Scheele first made it known. Previous to Scheele's experiments, however, it appears, that Lichtenstein had observed this acid when speaking of the *acid sugar of milk*, which he

Discovered  
by Scheele

says, "is a sugar of milk rendered impure by the acid of the whey, of which acid it may be deprived by repeatedly extracting from it alcohol or pure water."

Scheele, however, proved it to be an acid, and is therefore entitled to the discovery, for it is to him we are indebted for our knowledge of its characters and properties.

Milk, if left to itself to become sour, receives the greatest degree of acidity it is capable of in about fourteen days, which is the time this acid should be obtained.

Scheele, in order to obtain this acid pure, and knowing it impossible to effect this by a simple distillation, from its not being able to bear the heat necessary to raise it, and that in a less degree it only afforded a very small portion of a very weak vinegar, had recourse to more industrious means to obtain this separation. His method of obtaining it.

Being assured of the presence of an animal earth in whey, from the precipitate which lime water or caustic volatile alkali occasions in it, the whey evaporated to one half, and filtered to separate a remaining portion of caseous matter, had afforded him a precipitate of tartar on adding the tartarous acid; he concluded from this, that the whey contained alkali, or rather an essential salt, of which the alkali made a part; and this observation was further verified by the whey, reduced to a coal, having afforded him by lixiviation some alkali mixed with a little muriat of potash instead of its salt, which was destroyed by combustion. In short, he knew that it contained sugar of milk and a little mucilage; it was, therefore, necessary to isolate all these substances by processes incapable of altering it, and the success will be seen to have answered his wishes.

He first reduced the whey to  $\frac{1}{3}$  by evaporation, filtered it, and there remained no more caseous parts.

He then saturated the liquor with lime water, and the animal earth was precipitated. This liquor having been filtered and diluted with three times as much water, he added, drop by drop, some saccharine acid to it to precipitate all the lime, and he assured himself, by the addition of a little lime water, that there remained no more saccharine acid.

He then evaporated the liquor to the consistence of honey, and the thicker acid was redissolved in well rectified alcohol. The sugar of milk, and all the other substances foreign to the acid, which had not been dissolved by the spirits of wine, remained on the filter. At last, after having returned a little water to the acid held in solution by the alcohol, he distilled this last, and found in the retort some very pure lactic acid.

Objected to  
by Parmentier.

Parmentier and Deyeux say, that this process of Scheele to procure this acid very pure does not merit any confidence, as the complicated operation he employed so totally changes it's nature, that it presents none of the properties that belong to it; that it is rather a new acid that is formed, than the separation of an acid that previously existed. It is procured by congelation; but the acid obtained is always impure.

Scheele found that this acid afforded no crystals, even when reduced to the consistence of an extract, and when pushed to dryness it deliquesces.

It's properties.

On distillation, at first, some phlegm arises, then a weak acid resembling spirit of tartar, afterward an empyreumatic oil, and a new portion of the same spirit, some mephitic gas and inflammable air. In the retort a little coaly matter remains. It gives tokens of the presence of a little vitriolic acid, for if digested on lead, a light white sediment is formed in the solution, which is vitriol of lead.

With fixed vegetable alkali it forms a deliquescent salt (galacticum potassinum of Bergman) which is soluble in alcohol.

With mineral alkali, a salt (galacticum natratum) which does not crystallize, but is soluble in alcohol.

With volatile alkali, a deliquescent salt (galacticum ammoniatum) which, on exposure to the fire, loses it's ammonia before it's acid.

With barytes, lime, and alumine, it forms deliquescent salts; on the contrary, with magnesia, it gave some crystals which, however, deliquesced afterward.

It has no action, either in digestion or at the boiling point, on bismuth, cobalt, antimony, tin, mercury, silver and gold.

The lactic acid which has reposed on tin precipitated gold from aqua regia, of a black colour; it gave with iron a brown solution; with copper, a blue solution, which became green, and afterward changed to a dark brown; with lead, a harsh sweet solution like vitriol of lead; these are not crystallizable; with lime, however, it formed a crystallizable salt. As to the rest, Scheele remarks, that it disengages vinegar from the terra foliata tartari; and Bergman has given it a place between the formic acid and vinegar.

When Scheele had discovered the malic acid, he found the only difference between these acids to be, that the lactat of lime was soluble in alcohol, and malat of lime insoluble.

According to Bergman, it's affinities are to other bodies in the following order, in the *moist way*: Barytes, vegetable alkali, mineral alkali, ammonia, calcareous earth, magnesia, alumine, calx of zinc, iron, manganese, cobalt, nickel, lead, tin, copper, bismuth, antimony, arsenic, mercury, silver, gold, phlogiston, and platina. It's affinities, according to Bergman.

In the *dry way*. Barytes, potash, and soda, calcareous



earth, magnesia, the calces of metals, ammonia, and alumine.

Opinion of  
Morveau.

From these experiments and observations, it appears to Morveau, that whey is of itself, and independent of the salts it contains, an acid of a peculiar nature. Scheele seems to believe that it does not afford a perfect vinegar; but this is only because it wants the matter which produces the spirit in fermentation; Morveau has no doubt but that one part of it becomes vinegar, and he supports this opinion from these two facts:

1. If a bottle filled with milk be inverted in the same liquor, and be exposed to a degree of heat somewhat greater than that of summer, it furnishes mephitic gas, which, at the end of two or three days, is found to have converted the milk into curd. This proves that milk may undergo a complete fermentation without showing any evident traces of alcohol.

2. If six spoonfuls of good alcohol be added to about three pints of milk, and be exposed to a heat, well corked, giving vent from time to time to the gas of fermentation, the milk, at the end of one month, will be found converted into very good vinegar, which, after filtration, may be preserved in bottles. These two facts prove, according to Morveau, that the galactic acid, as he calls it, is the product of the acetous fermentation, and that if the milk was richer in spirit, the product of the various fermentations would be more sensible; but this does not prove the absolute identity of the galactic acid and vinegar; and Scheele informs us, that the lactic acid does not crystallize either with lime or soda; that it crystallizes with magnesia; that in distillation, it lets go the volatile alkali, and that it takes potash from vinegar, which announce an acid different from vinegar.

With respect to Morveau's ideas on this acid, he looks upon it as the production of a real fermentation, in proof

of which he remarks, that milk is retarded from becoming sour after having been boiled, or diluted with a large quantity of water. In these two cases, so contrary in appearance, Morveau asserts, that the affinity of the decomposing substance is equally prevented on the one part, by the abstraction of a portion of the fluid necessary to the intestine motion; on the other part, by the excess of the same fluid, which occasions a too great dispersion of the parts, which is very conformable to the progress of every fermentation.

No species of fermentation is sufficiently characterized by the nature of the produce, which is an acid. It is not that the milk is not also susceptible of the spirituous fermentation, but it is probable, that in this particular case, the passage from the first to the second fermentation is so rapid as not to be sensible, when the too easy diffusion of all the parts of the mass is not opposed by a mechanical motion. Whether this is the truth or not, it is, according to Morveau, impossible not to acknowledge a fermentation absolutely analogous to that which converts wine into vinegar; the agent, the manner of acting, the effects are all similar. This agent is the air, it acts by the affinity it exercises upon that of the principles of the milk, which ought to enter into the composition of its acid; this substance fixes the air, which we know to be the common acidifying principle, and from their combination, the acid whey or galactic acid arises.

Thus, Morveau affirms, that the whey did not exist in the milk, such as it is *found after the separation of the other constituent parts*.

Scheele's Chemical Essays, 1786—Encyclop. Méth. tom. 1. p. 1. Chimie art. Acide Galactique, p. 63.—Macquer's Wörterbuch von Leonhardi, neue Zusätze und Anmerkungen zu 1 ter. b. p. 753. art. Milchsaure, Molkensaure Leipzig, 1792.

Saccho-  
lactic acid.

*Saccho-lactic acid.*—On treating of the sugar of milk, when distilled with the nitrous acid; it was remarked, that a large quantity of a white powdery substance was mixed with the oxalic acid, which rendered the solution turbid; and which it was necessary to separate from the liquor by filtration, before the crystals of the oxalic acid could be obtained.

Discovered  
by Scheele.

This substance was discovered by Scheele to be a peculiar acid, to which the name of saccho-lactic acid has been given, or the acid of the sugar of milk.

Mistaken  
for an oxal-  
ate of lime.

The chemists who before Scheele had undertaken the analysis of the sugar of milk, had not even suspected the existence of such an acid, and although it was admitted by the illustrious Bergman as an acid *sui generis*, to which he has given the name of acidum galacto-saccharinum: Hermbstadt and Westrumb have looked upon it as a calcareous saccharite with an excess of acid, or an oxalate of lime. Indeed, from it's external appearance, Scheele himself had at first conceived the same idea, that it might be an oxalate of lime; particularly when he considered, that as a little of this earth always exists in milk, it might possibly be present in the sugar of milk; but experience soon convinced him to the contrary; for on pouring a little saccharine acid into a solution of the sugar of milk, no precipitation took place.

According, however, to Morveau, this observation alone appears not to merit all the confidence Scheele gave it; especially, if, as he supposes, the oxalic acid exists already formed in the sugar of milk: for it is evident to this chemist, that the addition of a new portion of the same acid, not being able to form a different combination; nor to unite to the salt, except to give it an excess of acid, would only favour it's solution, instead of producing a precipitation. If, however, the sugar of milk, as Morveau is of opinion, as well as common sugar, does

not contain the oxalic acid ready formed, the observation is more conclusive, although not decisive; since it is possible that the union of the lime with the other constituent parts of the sugar of milk is such, as not to be destroyed even by the oxalic acid itself.

The other proofs alleged by Scheele are the following, and appear to be decisive of it's being a peculiar acid.

1st. Having cast some of this earthy substance into a red hot crucible, it burned like oil, and scarcely left any ashes; whereas, according to Morveau, the oxalat of lime left a residuum of nearly half it's weight. Proofs of  
it's being a  
peculiar  
acid.

2d. It dissolved in 60 parts of boiling water; one-fourth of the portion dissolved crystallizes on cooling, and the remaining three-fourths are left in the cold water, *i. e.* one part of this earth is 80 of water: now it is certain that the oxalat of lime is much less soluble, and Bergman has observed, that it was not more so by the intervention of sugar.

3d. 240 grains of this purified substance in crystals being redissolved in 14400 grains of boiling distilled water the filtered solution manifested an acid flavour, reddened the infusion of litmus, and effervesced with chalk; but none of these properties belong to the oxalat of lime.

4th. Scheele distilled 120 grains of it in a retort, it melted very readily, became black, foamed considerably, and in the neck of the retort a brown salt was sublimed, which smelled like a mixture of benzoin and amber; and there remained 11 grains of coal. The receiver contained a brown liquor without any oily appearance; it had the same taste as the sublimed salt, in short, it contained some of it, which separated by a gentle evaporation. The sublimate weighed 35 grains, it had an acid flavour, dis-

solved readily in alcohol, but with more difficulty in water, and in the fire burned with a flame.

5th. Concentrated vitriolic acid distilled on this salt became black, foamed, and entirely destroyed it.

6th. This purified salt thrown in small quantities into a hot solution of potash, until there was no longer any effervescence, soon produced a quantity of small crystals. These were perfectly neutral; they only required for solution eight times their weight of boiling water, and when the water was cool, the greater part of them separated from it again. This substance did the same with soda, but only five parts of boiling water were sufficient to dissolve a portion of it.

7th. When saturated with ammonia, it afforded an ammoniacal salt, which after a gentle calcination was found acid on distillation; ammonia came over, which precipitated lime water.

8th. With earths it formed insoluble salts. Its aqueous solution decomposed the muriat of barytes, calcareous nitre, &c. but not vitriolated lime. These solutions were in turn decomposed by the salt resulting from the union of this substance with alkali.

9th. Finally, it acted the same with metallic calces as with earths; it also decomposed several metallic solutions, but not those of copper, iron, zinc, and magnesia in the vitriolic acid, nor those of tin and mercury in the muriatic acid.

Such are the properties by which Scheele supported his opinion of it's being a new acid, different from all the other known acids, particularly the oxalic; which opinion is now well-established: for, according to Morveau, it has neither the taste, form, solubility, nor power of the oxalic acid; nor is it the oxalat of lime, for this is a neutral salt without taste, and absolutely insoluble; nor is it a calcareous oxalat with an excess of acid, for in conse-



quence of this excess, it ought to act like this acid, when free, *i. e.* decompose vitriolated lime, vitriols of copper, iron, zinc, manganese, and the muriat of quicksilver; it ought more particularly to quit its earthy basis, when decomposed and resolved into its aeriform elements, whether by fire, or still better by the vitriolic acid; with the alkalies it ought to produce two distinct salts, different by their solubility, because it is well known that the alkalies cannot deprive this acid of lime, and we have seen that nothing of this sort took place.

Having given an account of Scheele's experiments; it will be now necessary to take a view of those of Hermstadt <sup>Hermstadt,</sup> in opposition to the former.

It has been said, when treating of the sugar of milk, <sup>Experiment and conclusion in opposition to Scheele.</sup> that Hermstadt as well as Scheele, had obtained an earthy substance from the sugar of milk, independent of the oxalic acid, which he obtained in crystals; on treating that salt with nitrous acid, 1290 grains of sugar of milk afforded this chemist 720 grains of this substance whenedulcorated and dried, which exceeds what Scheele obtained by one third, which Morveau thinks can only be attributed to a more perfect decomposition of the salt. In his first memoir Hermstadt has described this substance as composed of tender flocks, resembling very small crystals of selenite, of an acidulous flavour, of which they were not to be deprived by ebullition, and insoluble in water; he added, in his second memoir, that this substance was a white light earth, rough to the touch, somewhat sandy, like tartar of lime (*tartare calcaire*); that its flavour was somewhat acidulous, but weaker than that of cream of tartar; that it likewise had an earthy flavour resembling that of gypsum; that it did not appear soluble in saliva; in short, that it had all the appearance of calcareous tartar, or oxalat of lime.

Its insolubility in water was an important article, which Hermbstadt discussed again. He found,

1st. This *acid* earth, as he calls it, on being digested with distilled water, very little was dissolved; yet the acidulous and earthy taste of the water, and the small residuum, showed that some had been dissolved; evaporated and left to repose, it left a brownish saline particle, of an acid flavour like tartar, and which formed a precipitate with lime water.

2d. 140 grains of acid earth burned in a red hot crucible, until there were no longer any vapours, left 80 grains of a coaly residuum. This dissolved in nitrous acid, and filtered, and alkali added, 20 grains of white calcareous earth were precipitated, and there remained on the filter a black powder, which he took for burnt acid.

A little acid earth being exposed to the flame of a candle, it immediately swelled, gave suffocating vapours, and ran into a brown matter which tasted like common tartar; when thrown upon the coals in its fluid state, it burned with a white flame, decrepitated, and left behind a slightly insipid coal.

3d. In order to follow the method of Scheele, he distilled some of this acid earth in a retort; it melted, filled the receiver with subtile vapours; and having raised the heat afterwards, and then left it to cool, he found a brownish salt in the neck of the retort, of an acid and empyreumatic flavour; little soluble in water, more so in alcohol; which he attributed to an oily matter. In the receiver was a little brownish liquor, which had all the properties of an aqueous solution of the preceding salt. The residuum was a light coal like that left by sugar of milk; there were no traces of an alkali, but nitrous acid boiled upon it gave a precipitate of calcareous earth on the addition of an alkali.

4th. Hermbstadt had also supposed this acid earth to contain a superabundant acid, and to deprive it of it he had triturated 240 grains of it with a solution of potash, until it no longer effervesced, and the mixture had an alkaline flavour. The diluted liquor being boiled a few moments gave on cooling an *earthy deposit*; which edulcorated in hot water, and dried, weighed 330 grains, *i. e.* 90 grains more than at first. This increase of weight announced it's having united with alkali, which he confirmed by another experiment; for the same *earthy deposit*, put into a red hot crucible, soon became black, gave vapours of the odour of burned sugar of milk, and there remained a brittle saline mass, the solution of which afforded an alkaline liquor, and a little earthy precipitate like calcareous earth.

5th. He likewise poured some volatile alkali to excess upon this acid earth; it effervesced, but dissolved very little; diluted with distilled water, and exposed one hour to a sand heat, on cooling, a saline pellicle formed. The liquor having still the odour of the free alkali, he evaporated it to dryness, and found small confused crystals of a neutral salt. He remarks as a fact difficult to explain, that the saline or earthy matter had not increased in weight; it had not the acid flavour, observed by Scheele, which he attributes to the difference of the process.

Caustic volatile alkali, treated in the same manner with this acid earth, afforded no sensible solution or increase of weight; after a complete evaporation, the dried saline mass was acid as before; it contained no alkali, since an addition of two parts of potash disengaged no ammoniacal odour.

6th. Hermbstadt observed, as well as Scheele, that the solution of this acid earth was not rendered turbid by saccharine acid.

7th. He again treated this acid earth with vitriolic

acid, in order to convert the calcareous earth he supposed it to contain into sulphat of lime. He boiled 40 grains of concentrated vitriolic acid diluted with 48<sup>o</sup> of distilled water on 120 of this substance, and on leaving it to repose, there was a deposit of selenite. The liquor evaporated to one third deposited a thick black matter on the sides of the vessel, which was mostly decomposed saccharine acid; there afterwards separated, on cooling, some crystalline flocks of selenite, which washed and put on the coals gave not the least trace of saccharine acid. The rest of the liquor was pure vitriolic acid.

From these experiments, Hermbstadt concludes, that the acid earth is composed of calcareous earth, saccharine acid in excess, and a fat matter; that it is not a pure acid, as it would be more soluble, but an essential acid salt, of the nature of tartar or salt of sorrel, except instead of the alkali, it is the lime which serves as a medium of union between these principles; that it only differs from the sugar of milk, because this contains a greater quantity of acid dulcified by the fat part; that when sugar of milk is treated with the nitrous acid, the saccharine acid, united to this fat part, is set at liberty, and that the surplus remains combined with the calcareous earth; lastly, that the vitriolic acid has the property not only of depriving the saccharine acid of the calcareous earth, but likewise of decomposing it.

Morveau  
corroborates  
the opinion  
of Scheele.

These conclusions, drawn from Hermbstadt's experiments, have been examined by Morveau, who begins by stating, that Hermbstadt, in order to combat with advantage Scheele's system on the *saccho-lactic acid*, and, at the same time, to confirm the results of his first analysis, ought to prove,

1<sup>st</sup>. That the substance to which Scheele has given that name had a basis.

2d. That it's acid was the saccharine acid, and had all it's properties : which he had not done.

It appears to Morveau, that with respect to the calcareous earth which Hermstadt found, his experiments on this part are more conclusive than the rest ; and it is possible that sugar of milk contains some of that earth, if not essentially, at least accidentally. Scheickel found some in refined sugar. The sugar of milk which Morveau subjected to experiment came from Switzerland ; it was very white and perfectly crystallized.

He took some of the *acid earth* in it's greatest state of purity *i. e.* dissolved in boiling water, crystallized, and then redissolved ; into this he poured a few drops of lime water, to the point of saturation ; he then added some of the same acid until there was an excess of it ; he then left it to repose for 24 hours, to be certain that the salt which had formed was held in solution ; he then poured some common saccharine acid into it, and in a few hours there was a very sensible deposit that obscured the sides of the glass, which is usual with the saccharite of lime produced by precipitation. This proves two facts :

1st. That it was not the saccharine acid which held the lime in solution, or the addition of the same acid would have promoted instead of stopping the solution ; an acid never decomposes salts of it's own species.

2d. That it is impossible that the acid earth holds calcareous earth, since this acid earth cannot be collected except at the moment it swims in the saccharine acid ; and it is shown by this experiment, that this last acid deprives this acid earth of it's calcareous earth, and forms with it an insoluble salt. Thus, at most, it would be calcareous saccharite that is mixed accidentally with it, which it could not dissolve. Hence Morveau concludes, that this acid is really the saccho-lactic acid, which is different from the oxalic acid.



Morveau found, that to dissolve six grains of this acid completely, nearly one ounce of boiling water was necessary, and that it deposited about 14 in a more crystallized form on becoming cool: this liquor very sensibly reddened blue paper; its specific gravity at 12° was 1,0015. It effervesces with the carbonated earths and alkalies, and forms with them neutral salts, which have been called saccholaëtats by the French chemists.

As this acid can only be dissolved in small quantity, it cannot have any action in a liquid state upon the metals; it unites better therefore with their calces, and forms salts with them very little soluble.

Fourcroy's  
definition of  
it.

Fourcroy in his Philosophie chimique, has thus defined it. The saccholaëtic acid is precipitated in the form of a white powder, from the oxalic acid formed by the sugar of milk, and the nitric acid; it is very little sapid, very insoluble, decomposed by means of fire, and affords a sublimed salt of the odour of benzoin; it forms crystallizable salts with alkalies, that are very little known.

It's affin-  
ities ac-  
cording to  
Bergman.

The order of it's affinities, according to Bergman, is the following:

*Moist way.*

Lime  
Barytes  
Magnesia  
Potash  
Soda  
Ammonia  
Argile  
Metallic calces  
Water

Alcohol  
Phlogiston.

*Dry way.*

Lime  
Barytes  
Magnesia  
Potash  
Soda  
Metallic calces  
Ammonia  
Argile.

This chemist observes that the order of the earths is very difficult to determine, from the small solubility of the salts resulting from their combinations.

That it gives up the calcareous earth to seven acids,

viz. the saccharine, oxalic, vitriolic, tartareous, karabic, phosphoric, and ouretic.

That it decomposes the nitres of silver and mercury, and the nitre and muriat of lead.

That by double affinity it decomposes all the metallic salts, when it is in the state of an alkaline neutral salt.

Morveau is of opinion, that this acid is formed of the acidifying principle oxygen, and a radical or acidifiable basis; and that every thing concurs to indicate, that the sugar of milk contains only the saccholarctic radical, which being different from the saccharine radical, constitutes all the difference between the sugar of milk and common sugar.

Scheelii Opusc. chem. et phys. T. 11. p. 111.—Hermstadt's Phys. und chem. Abhandl. T. 1. p. 301.—Encyclopéd. Méthod. Tom. 1. Chimie, p. 288 to 293.—Philos. Chimiq. p. 71.

*Bombic acid*.—It had been mentioned by the Abbé <sup>Bombic acid.</sup> Boissier de Sauvages, in treating of the disease of the silk-worm, which the French call *muscardine*; that on tasting the humour of one of these diseased insects, which he had cut in two, he found it to impress on the tongue a very strong degree of acidity, but he looked upon it only as the effect of the disease, and perfectly foreign to the organization of the insect.

In 1781, Chauffier being desirous of making a few ex- <sup>Discovered by Chauffier.</sup>periments on silk worms, had bred a certain quantity of them for that purpose. Several of these having escaped from the paper cases, got into an adjoining chest of drawers, where having peaceably spun their silk, they underwent the other two changes. Having some time after looked into the drawers, to his great surprise he found several leaves of blue paper with red spots, as if some acid

had been sprinkled upon them. This excited his curiosity; and on seeing several of these insects in their butterfly state attached to this paper, he suspected that they might contain some acid liquor, which was necessary in performing some function, and which they shed during their metamorphosis into a butterfly. This suspicion was soon verified, for on enclosing a few of them in cases of this blue paper, when they were about to undergo this change, he observed the paper to be moistened, and changed in spots to a red colour; and hence arose the discovery of the existence of a disengaged acid in the silk-worm, called the bomic acid.

The part of  
the insect  
that supplies

Chaussier, in order to find whence this acid liquor proceeded, examined the viscera of this insect, and found that the lymph, which in the caterpillar state circulated in a spongy texture, situate between the skin and the stomach, was collected and deposited by degrees, as the animal was preparing for it's chrysalis state, in a new reservoir situate near the anus; and was formed at the time when the animal, pressed by the necessity of voiding it's reservoirs of the gummy juice, lays the first vestiges of it's silk.

It's colour.

Accumulated in this reservoir of the chrysalis or rising butterfly, it is of an amber colour, of a peculiar flavour, and slightly mucous; in short, says Chaussier, "it is a free acid which immediately reddens the blue tinctures of vegetables, unites with effervescence to aerated alkalies, dissolves certain metals; treated on the fire with alcohol, according to the process of Landriani, produces a sort of æther; is reduced to a gas, and finally, has all the properties characteristic of acids.

Method of  
collecting it  
from the  
chrysalis.

Having satisfied himself respecting the origin and seat of the acid, Chaussier was desirous of finding the best method of collecting it; and he first began by cutting the chrysalis in two, in order to separate that part which

contained the acid, but as it immediately changed the steel to a black colour, and had the inconvenience of making his fingers black as ink, which continued several days; and besides, as it would have soon become putrid, like all other animal acids extracted by expression, by holding in solution some mucous parts, this academician made use of another process to obtain the liquor. He bruised 15 oz. of healthy chrysalides recently drawn from the silk-cods, in a glass mortar; and by expressing them through a linen cloth, obtained 9 oz. of a thick yellowish juice, very strongly acid.

The chrysalides which are not drawn from their cods till after the winding of the silk, and have been exposed to the heat of the furnace, or the vapour of boiling water, still afford the same liquor.

To deprive this liquor of it's mucous parts, which would not only diminish it's dissolving energy, but dispose it to putrefaction; he added 2 oz. of alcohol to it. The mixture at first was warm, but soon became clear; and being filtered, the liquor was clear, of a beautiful orange colour, and of an odour approaching that of the silk worm or mulberry tree. Into this filtered liquor some more alcohol was poured by degrees, and at each time there formed a slight white precipitate, which was nothing but a gummy substance. This was continued until no more precipitate appeared, for which 3 ounces and half were necessary.

The different deposits that remained on the filter weighed one ounce and a half; and the surface resembled an oil of a beautiful orange colour, of the odour of the silk worm. This oil was insoluble in spirit of wine, although it coloured it somewhat; one part was of a gummy nature, and soluble in water, the other part appeared to Chauffier to be a sort of animal gluten, intimately united to an earth and a fat oil.

To obtain it  
pure.

Instead of bruising the chrysalides they may be simply infused in alcohol. In a short time the acid unites to the spirit, is of a beautiful transparent orange colour ; and as the acid is more fixed than the spirit, by evaporation by a gentle heat a very pure acid is obtained, which concentrated by evaporation in the air, and purified from the mucous matter by repeated filtrations, is no longer subject to change.

The acid  
exists in  
every state  
of the insect  
according  
to Chauffier.

Having satisfied himself of a free acid in the chrysalis, he was desirous of knowing whether it exists wholly formed during all the ages of the insect, or only on passing to the chrysalide state. He had at first embraced the latter opinion, founded on this circumstance, that the distillation of 12 oz. of silk worms in the fourth age only afforded some phlegm, an empyreumatic oil, and volatile alkali ; without any evident vestige of an acid, or even of a gas, that might have announced the decomposition of the acid. But he received no more on distilling the chrysalides themselves, in which the acid is so developed ; on the other side, the coaly residua of both operations, lixiviated in boiling water, furnished a neutral ammoniacal salt ; and even the eggs of the silk worm, when digested in water mixed with a little alcohol, afforded him some feeble but evident marks of acidity.

Hence he thinks he is enabled to conclude, that the acid principle exists at all times during the life of the insect, but in a different manner ; in the egg and in the worm it is combined with a glutinous gummy substance, and it cannot be recognized without precipitating this substance, which marks it's properties, as by the infusion of alcohol, whilst nature performs this operation in the disease called the *muscardine* ; but in the chrysalis the acid is always free and developed, and immediately shows it's acid properties.

Objected to

This conclusion of Chauffier appears to Morveau to



have several objections; for example, it is not known <sup>by Morveau.</sup> what becomes of the acid in the distillation, which is found at least in excess in the chrysalis; nor is it more easy to conceive how this acid should be able to form with the volatile alkali an ammoniacal salt, that could resist a distilling heat, without even being sublimed; in short, Morveau is of opinion, that the eggs of the insect, after their maceration in water and alcohol, may leave some traces of an acid, without it's being the same as that of the chrysalis. As it has been proved that this last is very abundant and manifest, he is inclined to believe, that before this metamorphosis, the animal contains only the acidifiable base, which afterward passes to a state of perfect acid, by combining with the acidifying vital air, by means of some functions peculiar to the new organization of the insect.

This acid attacks iron, lead, and copper, with which <sup>It's action on the metals.</sup> it forms, according to the French nomenclature, bombiats, and in the definition of it given by Fourcroy, it is said to undergo a spontaneous decomposition, affording the prussic acid by distillation and nitric acid, but unknown at present in it's combinations.

Mém. sur un Acide particulier découvert dans le ver-à-foie, avec des observations sur l'origine, le siege de cet acide, &c. par M. Chauffier, Nouv. Mém. de l'Acad. de Dijon, acc. sem. 1783, p. 70.—Encyclopéd. Méthod. art. Chimie, T. 1. p. 410.

*Lithic Acid.* For the discovery of an acid in the cal- <sup>Lithic acid</sup> culus of the bladder, we are indebted to the labours of Scheele and Bergman. It is called by Morveau, in the Encyclop. Méth. the lithic acid, from λιθιας or λιθος, which chemists and physicians have made use of as a radical

word in their account of the calculus. By some chemists it is called the uric acid.

It's properties.

The lithic acid is a body composed of small needles, closely compressed together, forming very dense laminæ, susceptible of a polish like marble. It is of the colour of wood, is nearly insipid, and weakly reddens the blues of vegetables. It is insoluble in cold water, but soluble in more than 1000 times it's weight of boiling water; it crystallizes on cooling. It is soluble in the nitric acid when a little concentrated, which gives it a rose or pink colour; this is communicated to the skin, and when evaporated, a rose coloured deliquescent residuum remains. It is insoluble in the sulphuric and muriatic acids. It is soluble in caustic vegetable and mineral alkalis, and may be precipitated from them by the weakest acid, even by the carbonic: hence it is insoluble in alkaline carbonat, and is the weakest of all acids, which distinguishes it from every other.

On distillation, it is in part decomposed, affording the carbonat of ammonia in small quantity, and the prussic acid, and is in part sublimed into an acid sublimate.

It unites to earths, metallic acids, alkalis, forming with them peculiar neutral salts, called lithiats of ammonia, of lime, of copperas; but it appears to prefer the alkalis to the earths.

Observed by  
Leuwenhoeck.

Although Scheele may be looked upon as the discoverer of this acid, yet Leuwenhoeck had observed, before him, the crystalline deposit which took place in water in which a calcined vesical calculus had been boiled; but he had no idea of it's being an acid.

Where  
found.

The lithic acid is found to compose the greater part of human urinary calculi, as well as the chalkstones formed in the gout. Sometimes it forms only the central part of the calculus, and is covered with earthy phosphats; at other times it is deposited upon a nucleus of

oxalat of lime. It has not at present been found, according to Fourcroy, in other animals. It exists in all human urines, and is precipitated from them in the form of red sand, on cooling; it is more abundant after acute diseases. It is this acid, according to Fourcroy, that forms the critical deposit of urines; it is most often found forming gravel in the kidneys. It is dissolved on being suspended in a ley of very pure potash, greatly diluted with water, which may be injected into the bladder. It appears to be naturally united in urinary calkali with a coloured animal substance, which would seem to be uree, but in very small quantity. In the chalkstone it is united with soda; and on distillation this acid is decomposed, and yields the usual products of other animal substances, viz. a fetid alkaline liquor, a heavy fetid oil, volatile alkali, and a spongy coal; this last, on incineration, fuses into a white salt that does not deliquesce, is intirely soluble in water, is alkaline, and when saturated with nitrous acid, gives rhomboidal crystals; hence it is soda, the other part of the chalkstone.

It had been suspected by Fourcroy, that this acid was nothing but a modification of another acid; and from a late experiment of Brugnatelli, this suspicion was true. He found that the lithic acid was converted into the oxalic acid with astonishing rapidity, on suffering it to come into contact for a few minutes with oxygenated muriatic acid gas; this experiment has been repeated by Fourcroy, and confirmed. He placed a little powdered uric calculus in a tube of glass, moistened it, and on passing some oxygenated muriatic acid gas through it, the conversion immediately took place.

Conversion  
into oxalic  
acid.

Leonhardi's Wœrterb. v. 5. p. 238. art. Blasensteinsäure.—Fourcroy's Elémens de Ch. T. 4. art. Acide Li-

thique. 1791.—Ency. Meth. art. Acide Lithiasique, Tom. 1. p. 1, 410.—Annal de Chim. No. 95. p. 184, 216.

Amniotic  
acid.

*Amniotic acid.* This acid was first discovered in the liquor amnii of the cow, by Buniva and Vauquelin. The small quantity they were able to procure prevented them from extending their experiments upon it, or from ascertaining the quantity of it's component parts; but the investigation was sufficient to convince them of it's being a peculiar acid.

It's proper-  
ties.

The amniotic acid is a white, shining, concrete substance; it's flavour is very slightly acid.

It changes the tincture of litmus to a red colour.

It is very little soluble in cold water, much more so in boiling water, from which it separates on cooling, in the form of needles, several centimetres in length.

It readily combines with caustic alkalis, which render it very soluble in water; the other acids separate it from it's saline combinations, in the form of a white crystalline powder; it does not decompose alkaline carbonats, except by means of heat; it produces no change in the aqueous solution of alkaline earths, or in the nitric solutions of silver, lead, or mercury.

Exposed to the fire, it swells and emits an ammoniacal odour, evidently mixed with prussic acid; a large volume of coal is left behind.

It's relation  
with other  
acids.

It would appear at first to have some relation to the saccholactic and uric acids; but this is soon found to be only externally, for the saccholactic acid, on distillation, affords no ammonia; the uric acid, indeed, gives both ammonia and the prussic acid, on exposure to the fire, but it is not so soluble in hot water, does not crystallize into long, white, and shining needles, and more particularly, is not soluble in boiling alcohol, like the amniotic acid,

Des Propriétés de l'acide contenu dans l'eau de l'amnios de vache, appelée *acide amniotique*, dans un mémoire sur l'eau de l'amnios, &c. par les Cit. Buniva et Vauquelin, An. de Ch. N<sup>o</sup> 99. p. 279. An. 8, or 1800.

*Acid of phosphorus.*—This appellation has been given by chemists to this acid, because it was first obtained by combustion from an inflammable substance called phosphorus, which, when pure, is a white transparent body, resembling wax. It is sometimes crystallized and very fusible. Phosphorus undergoes two species of combustion. 1st. If it be exposed to the common air of the atmosphere at the lowest temperature, even a few degrees below zero, during the day a white smoke or vapour is seen to surround it; if during the night, this vapour appears in the form of a greenish white waving light; and in perfect darkness, the luminous rays are so expanded as only to disappear at some distance from the phosphorus. This luminous vapour is unaccompanied by any sensible heat, and does not communicate flame to other combustible bodies, but continues to burn and emit light to the last atom. This is called the slow combustion of phosphorus, and if it be made in an apparatus under a glass bell, where the air can be slowly renewed by lateral apertures, the acid which is formed, and is dissolved by the humidity of the air it attracts, is the *phosphoric acid*. 2d. If the temperature in which the phosphorus is exposed to common air be raised above 40 degrees, or even somewhat lower, this slow combustion soon gives place to a rapid combustion, a deflagration takes place, accompanied by an asperision of numberless flashes, and very vivid luminous decrepitations; the fusion is complete, and the heat very ardent that arises from it, and the product is the *phosphoric acid*. This rapid combustion is, however, more complete in oxygen gas. Phosphorus when plunged into

Phosphorus  
undergoes  
two kinds  
of combustion.



this gas, does not burn in the cold, but if when melted it be placed in contact with it, it immediately inflames, and the light is so strong as to be insupportable to the eye; and so great is the quantity of heat, that according to Lavoisier and Laplace, one pound of oxygen employed in the combustion of this body furnishes a quantity of heat, capable of melting 66 lb. 10 oz. 5 drachms and 24 grains of ice at zero. This phosphorus absorbs once and a half it's weight of oxygen, and is converted into white, snowy, crystalline flocks, which are the acid. If this phosphorus thus melted be burnt at the bottom of water by communicating oxygen to it, the acid is dissolved and puts on a liquid form.

It's purification.

Since phosphorus, when first made by artificial means, is not in it's pure state, methods have been discovered to rid it of it's impurities. Some recommended the rectifying of it by distillation, it was put into a small glass retort, to which a receiver half filled with water was applied, and a gentle heat forced over the phosphorus; but whatever precaution was used, a part of the phosphorus is always lost by being converted into acid. Another method is, to melt it in hot water a little below ebullition; it is then poured into cold water, taking care not to let it come into contact with the air, as mischief might ensue from it's inflammation; then cut in pieces, put into tubes and liquified again in hot water, and when cold taken out; by this means the impurities being lighter than the phosphorus, separate. A third method is to put the phosphorus into some chamois leather, which is to be dipped in boiling water till the phosphorus is melted; it is then to be pressed through the leather in the manner quicksilver is purified; but the leather can be employed only once, as it colours the phosphorus the second time; this method was recommended by Pelletier. It is then put into a long-necked glass tunnel, which is closed at the smaller end by a piece of

wood or cork, filled with water and placed in boiling water; during fusion it takes the form of the tunnel; it is afterwards plunged into cold water, and when fixed, the phosphorus is thrust out by a bit of wood. It is preserved in water, although after a certain time it loses its transparency, is covered with a white powder, and the water becomes acid. The red impurity observed to attend phosphorus, and which is of all shades to a black, arises from its union with more or less charcoal, according to Proust, and not from iron, as Nicolas supposed.

Fourcroy found the specific gravity of phosphorus to be to water as 2,0332 to 1,0000. Its flavour is somewhat sharp and disagreeable, it has a garlic smell, crystallizes either in the form of needles or micaceous laminæ, or lengthened octoedrons, presenting a great variety. It is very susceptible of heat. At  $25^{\circ}$  of Reaumur, it is soft and ductile; at  $32^{\circ}$  it melts, runs, and is transparent, like a white oil; on becoming cold by degrees, it crystallizes; at  $76^{\circ}$  it is reduced to vapours; at  $86^{\circ}$  it begins to collect in drops at the mouth of the retort, which has been heated by water. Heated without water, in a stone retort, it boils at  $230^{\circ}$ , the drops following each other very quick at the mouth.

According to Spallanzani, it does not begin to burn below  $5^{\circ}$  of Reaumur in common air; and in pure oxygen gas, it burns and produces light only at  $22^{\circ}$ .

The reason of its burning sooner in common air than in oxygen gas, arises from its solution by the azot of the first, which becomes saturated with it; it then burns in oxygen gas; hence in pure oxygen gas alone, no phosphorous acid can be obtained.

Phosphorus being thus procured in its pure state, the next object is to obtain the acid from it. In the articles *urine* and *bones* it was observed, that this acid might be obtained from both, although the preference was given to

Three methods of obtaining the acid from phosphorus.

the method of Scheele; but the tediousness of the operation when any great quantity of phosphoric acid is wanted for medical or other purposes, and the admixture of foreign matters, and other great obstacles against procuring it in a state of purity, independent of the expense, oblige the apothecary, who wishes to procure several pounds of it in a short time, to relinquish the attempt of decomposing bones, and to endeavour to oxygenate ready-prepared phosphorus. For this purpose there are three methods, either by the combustion of phosphorus, it's gradual oxygenation by exposure to the air, or finally, it's treatment with nitric acid.

By combustion.

1st. The first method of obtaining this acid, *i. e.* by the combustion of phosphorus in a proper apparatus, was recommended by the late Pelletier and professor Tromsdorf, and is a good way of obtaining it in a state of considerable purity. This mode, however, cannot be conveniently practised by every body, since, according to Pelletier, it requires a very complicated apparatus; besides the combustion of phosphorus is ill adapted for the speedy preparation of large quantities of the acid, so that, upon the whole, it cannot be recommended as a method to be universally adopted by all.

Slow oxygenation.

2d. The second method, *i. e.* by the slow spontaneous oxygenation of phosphorus, costs very little trouble, not more than that of frequently examining the temperature of the place in which the phosphorus is left to liquefy. It is, however, necessary, to be cautious not to expose too large quantities of phosphorus to be oxygenated at once, nor to suffer the pieces of phosphorus to come into contact with each other; for, according to Suerfen, it has happened to him more than once, that having placed about one ounce of phosphorus in a glass funnel, in a cellar, it took fire at the temperature of 50 degrees of Fahrenheit. The phosphorous acid thus obtained may

afterward be converted into phosphoric acid by distillation, according to the method of Buckholtz. Though phosphoric acid may thus be obtained in a very pure and concentrated state, this method is, however, not calculated to become a general rule of practice, for it requires still more time than the first method, or the combustion of the phosphorus, independent of the danger of spontaneous inflammation.

3d. The third method, *i. e.* by the nitric acid, is <sup>By nitric acid.</sup> looked upon as preferable to the others, for it not only procures whatever quantity is wanted, with certainty, in a very short space of time, but without much expense, scarcely any trouble, and without any hazard of loss. This is the method made use of by Suerfen, an ingenious apothecary, at Keil, by which he has been enabled to procure, in the space of a few hours, as large a quantity of pure and concentrated phosphoric acid as he formerly could scarcely prepare in a week, or even a fortnight, and that not without a great deal of labour and expense; hence it must be of great use to the practical chemist.

Although in the oxygenation of phosphorus by the nitric acid, according to professor Tromsdorf, caution is necessary, yet it need not be carried to that extent which he asserts. If, for example, highly concentrated nitric acid be poured upon a considerable quantity of phosphorus, and this mixture be afterwards exposed to a violent degree of heat in the sand bath, an inflammation of the phosphorus will almost unavoidably be the consequence, as the action of the large mass of phosphorus upon the nitric acid being too vehement, a considerable part of the former is impelled toward the surface, where coming into contact with the atmospherical air, an inflammation is produced with such an extrication of heat and air, as violently to break in pieces the vessels in which the distillation is performed. The same circumstance will like-

wife happen, if, according to the directions of Hermbstadt, 4 ounces of fuming nitrous acid diluted with 18 ounces of water, be poured upon 1 ounce of phosphorus in a retort, and the mixture be distilled in a sand bath. In this case, at first, no action of the phosphorus upon the acid is perceptible; but in the progress of the distillation, as the nitrous acid becomes more and more concentrated, it's action is so instantaneous as to impel the phosphorus with violence to the surface, where it immediately takes fire, and the loss of the retort with all it's contents is the consequence.

As, therefore, it is extremely difficult to obtain phosphoric acid in this manner, and in general, to perform the operation by means of the sand bath, the best is to follow Lavoisier's method, viz. to pour the nitrous acid into a tubulated retort, and gradually to introduce the phosphorus by single drops at a time. By following this method, with some variation, a considerable quantity of phosphoric acid may be prepared with the utmost security, and with very little expense of time; the process may be even carried on in the intervals of the time employed upon other operations.

Method of  
Suerfen.

Suerfen, after having procured some pounds of concentrated nitric acid, free from all admixture of sulphuric by drawing off, separately, the acid which passes over in the middle of the operation, dilutes several ounces of this acid with an equal quantity of distilled water. This diluted acid is then poured into several small glass receivers, an ounce into each, which are placed upon a frame made of iron wire. Half an ounce of phosphorus is now introduced into each of these receivers, which are gradually heated by the flame of a small lamp, till a sufficient action of the phosphorus upon the nitrous acid is perceived; a considerable evolution of nitrous gas immediately takes place, which, however, is not so violent.



as to impel the phosphorus to the surface of the liquid. If, in any of the receivers, the solution of the phosphorus does not seem to go on as it ought, they are heated by applying the lamp to them, and after some time, if there is reason to apprehend that too great a degree of heat may be produced, the lamp is intirely removed. Should the action in the receivers become very violent, and luminous vapours disengage themselves, it may be immediately allayed by the addition of a small quantity of distilled water. Thus the phosphorus must be introduced into the acid by small quantities at a time, alternately heating the receivers with the lamp, till the reciprocal action of the acid and the phosphorus becomes languid, when a fresh quantity of concentrated nitric acid is again added. This alternate introduction of the phosphorus, the nitric acid, and the distilled water, with the application of the lamps, whenever it is required, are continued till the whole quantity of the phosphorus to be oxygenated is expended. For the complete oxygenation of an ounce of phosphorus, four ounces of fuming nitrous acid of 1,508 sp. gr. are generally required, in a temperature of  $61^{\circ}$  of Fahrenheit, and a space of four hours. In six small receivers, and with one lamp, 12 ounces of phosphorus may be very conveniently oxygenated in one day, reckoning eight hours to the operation. This phosphoric acid, which is of a dilute quality, and mixed with a small quantity of muriatic and nitric acids, is now subjected to distillation upon the sand bath, in which, at first, muriatic acid gas, then nitrous acid, and nitrous gas, and afterwards an insipid water pass over. If the distillation be now continued with an increase of heat, an acidulous fluid passes over, while pungent vapours are extricated. These vapours have an odour precisely similar to that of the phosphoric acid when passing into a state of volatilization.

The acid which passes over at the beginning of the distillation produces no cloud when mixed with lime water; that, on the contrary, which is given out at the end of the operation, precipitates from it a very copious sediment; a proof of the acid last extricated being of a phosphoric nature; and it appears to Suerfen as well as to professor Scherer, that by a very great increase of temperature, a partial decomposition of the phosphoric acid is effected. The whole process being now completed, the product is a colourless phosphoric acid, of the consistence of a thick sirup, the specific gravity of which, at the abovementioned temperature, is 2,0: and from one ounce of phosphorus 2 ounces and half of concentrated acid are obtained, soluble in water with an extrication of heat, possessing all the properties of pure phosphoric acid. Such is the process made use of by Suerfen.

Division into two acids.

The acid of *phosphorus*, according to the degree of oxygenation it has undergone, may be divided into the phosphoric and phosphorus acids. The first, or *phosphoric*, according to the definition of Fourcroy, is a thick liquid composed of phosphorous and oxygen, united by rapid and complete combustion, or by any other means; or it is solid, vitrifiable by the fire, dissolving silex in it's vitrification, and decomposable by carbon, which recalls it to a state of phosphorus again; it decomposes the nitrous acid, and becomes oxygenated to excess by taking a part of it's oxygen. This oxygenated phosphoric acid is decomposed by the flame of a candle, producing a very strong detonation; the moment it's oxygen is raised to a gaseous state, it forms phosphats, with earths, alkalis, and metallic oxyds. The second, or *phosphorous*, differs from the phosphoric acid only by having less oxygen in union with it; it is very volatile, acedous,

taking and giving oxygen to many bodies, and forming phosphats with earthy, alkaline, and metallic bases.

1st. The *phosphoric acid* is a thick liquid, nearly viscous, forming strizæ, like certain oils, on the sides of the glass in which it is shaken; it is perfectly inodorous, very sour, but not caustic to the taste, never burning any organic substance; it's specific gravity is more than twice that of water; it reddens the blue colours of vegetables, is perfectly incombustible, and enjoys, in a high degree, that property of attracting and of being strongly attracted, which the genius of Newton has attributed to acids. <sup>Phosphoric acid.</sup> Exposed to heat; it becomes thick, concentrated, dense, <sup>It's properties.</sup> and loses it's water, which evaporates, taking at the same time a very weak part of the acid along with it. It is thus brought to the state of transparent jelly, preserving this form in a well corked vessel, but in the air becoming liquid again. If it be still exposed to heat until red hot, it melts, swells, is filled with blebs, and at last it remains in tranquil fusion. Before the blowpipe, upon a platina spoon, or in the hole of a piece of charcoal, it is likewise made to take the form of a very transparent vitreous globule, resembling the most beautiful water crystal. In this state of glass, the phosphoric acid imitates, in brilliancy, the precious stones, but it is always acid, deliquescent in the air, and soluble.

The phosphoric acid, if it be immediately produced by dry combustion in oxygen gas, attaches itself to the sides of the glass bells in which the heat has sublimed it before inflammation, in the form of very acrid, white, brilliant, crystallized scales; but it soon loses this form, and becomes liquid by contact of the least humidity, even of the air. It is necessary to observe, that concrete and lamellated phosphoric acid immediately melts into glass the moment it becomes red hot, without swelling, or emitting blebs, because it has no water to lose, <sup>In a liquid and vitreous states.</sup>

or at least, very little previous to it's taking the vitreous form.

This singular vitreous state, of which the phosphoric acid is susceptible, in no manner changes it's nature, or the proportion of it's principles; it is a proof of it's great fixity, and if it is strange that it contains a substance so volatile as phosphorus, it must be recollected, what a solidity the oxygen has acquired by losing such an enormous quantity of caloric. As to the rest, the vitreous phosphoric acid is only obtained very pure, when it is the product of phosphorus burned by oxygen, and when melted in a crucible of platina; when extracted from it's union with some body, it often retains a little earthy, alkaline, or even metallic basis, with which it was joined. When melted in earthen, glass, or metallic vessels, it dissolves a part of them, affording on fusion opaque, coloured glasses, that are insipid, insoluble, do not deliquesce in the air, are odorous and luminous on being rubbed in the dark. When a very pure phosphoric glass is dissolved in water, it does not differ in the least from the liquid phosphoric acid of which it is made. The glass once made, is fused without motion or vapour; when red hot, it is even so fusible as to serve as a flux for many other bodies.

It's action  
on different  
bodies.

Light has no action upon phosphoric acid, which refracts it pretty strongly. It has not, in it's different states, any attraction for oxygen with which it is entirely saturated, nor any action on oxygen gas. Exposed to the air, it only attracts it's humidity; which the dry and concrete takes from the air with great rapidity and force; the thick liquid or gelatinous acid attracts it more slowly, but absorbs nearly half it's weight; the vitreous only becomes humid after a long time, and when it's exterior stratum is thick and gelatinous, it defends the interior so as to preserve it's form a long time, and only takes the



liquid state with great difficulty. It undergoes no change from azot, or it's gas, or from hydrogen, or it's gas. Carbon has likewise no effect upon it in the cold; but in the heat, when the charcoal is red hot and touches the acid in it's dry or vitreous state, the order of attraction changes, the carbon deprives the phosphorus of it's oxygen, which is volatilized, whilst the newly formed carbonic acid is disengaged.

Such is the theory of the process by which phosphorus is obtained on distilling the dry phosphoric acid with charcoal. The decomposition of this acid by carbon, agrees with it's formation in proving it to be composed of 0,39 of phosphorus, and of 0,61 of oxygen. Phosphorus cannot be combined with this acid directly, either in the cold or by heat; yet this acid seems to unite with a greater quantity of phosphorus, in order to become phosphorous acid; but this is only by uniting a little oxygen to the phosphorus at the moment of it's burning, and not by adding immediately more phosphorus to the phosphoric acid. Sulphur has no action upon it, nor is the diamond affected by this acid when melted and kept a long time at a red heat. This acid forms no union with carbonic acid, or it's gas; it, however, disunites it from most of it's combinations; thus it separates it from water, producing an effervescence in acidulous waters, natural or artificial. Water has a great attraction for this acid; when in dry white flakes, it dissolves in a small quantity of this fluid, producing a noise like that from a red hot iron plunged into water, and disengages a great deal of heat. The vitreous acid is longer in dissolving, but the liquid concentrated phosphoric acid unites with it almost without heat, and slowly. These two bodies may be united in all proportions. The acid loses more of it's favour, density, weight, and strength, in proportion to the quantity of water added. The water is only sepa-



rated from this combination by means of heat; it is much more volatile than the acid, which is concentrated in proportion to it's disengagement, in the form of vapour. The acid, during the evaporation, passes successively through the states of thick liquid, viscous fluid somewhat gelatinous, and glass.

Earthy and  
alkaline  
phosphats.

The phosphoric acid forms with alkalis and earths salts, the generic characters of which are, to afford no phosphorus when heated with carbon, but be fusible into opaque or transparent glasses; they are phosphorescent at a high temperature, are soluble in the nitric acid without effervescence, are precipitated from this solution by lime water, and are called *phosphats*. The phosphat of potash is not crystallizable, but deliquesces, and affords, with lime-water, a precipitate soluble in acids, without effervescence. Phosphat of soda is very crystallizable, effloresces, is very fusible before the blowpipe, affording an opaque glass on cooling, giving the same precipitate as the preceding by limewater, easily taking an excess of soda; it is purgative. Phosphat of ammonia is crystallizable, decomposed by heat, which melts it into a transparent acid glass; it affords phosphorus with carbon. Phosphat of soda and ammonia; this exists in animal fluids, is very crystallizable, affording by lime an insoluble precipitate and an ammoniacal vapour at the same time. Phosphat of magnesia is crystallizable, has a sweetish taste, very little soluble, uniting, although very neutral and saturated, to ammonia, into a sort of triple salt; it exists in human urine. P. ammoniaco-magnesian is very little soluble, without favour, often deposited in human vesical calculi, in the form of white spathic strata, affording an ammoniacal vapour, and magnesia, by the contact of caustic alkalis. P. of glucen is sweetish to the taste, and affords, by means of lime, a precipitate soluble in carbonat of ammonia. P. of alumin is of a thick and gelatinous

consistence, and yields a precipitate to all the bases, which is redissolved by caustic alkalis. P. of flex is in a vitreous state resembling a gum, is insipid and insoluble, only becoming soluble in acid after having been melted in four times it's weight of alkali. P. of lime is insoluble and insipid, forming a kind of porcelain when exposed to a great heat, existing, in it's natural state, in the form of stones, and sometimes crystallized; it is insoluble in phosphoric acid, and passes to the state of acidule by the other acids. Acidulous P. of lime is sour to the taste, is in the form of scales resembling mother of pearl, is insoluble, and not to be decomposed by acids. P. of strontian is insoluble, it reddens the flame of the blow-pipe, and is decomposed by lime and barytes. The component parts of the phosphats are as follow:

Phosphat of strontian	—	Phosphoric acid	-	41.2
		Strontian	-	58.76
of lime	—	P. a.	-	41.
		Lime	-	59.
acid of lime	—	p. a.	-	54.
		Lime	-	46.
of soda and ammon.		p. a.	-	32.
		Soda	-	24.
		Ammonia	-	19.
		Water	-	25.

No metal can unite with the phosphoric acid in it's metallic state; the acid undergoes no change with metals at any temperature. Several of them, however, acquire, by the addition of this acid, the property of decomposing water, and of disengaging the hydrogen from it in the form of gas, absorbing it's oxygen. On heating the most combustible metals with the vitreous phosphoric acid, although none of them has really more attraction for the oxygen than phosphorus had, there is, however, by means of a double attraction, a formation of oxyd

Metals and  
their phos-  
phats.

and metallic phosphorus. To obtain this kind of composition, three parts of metal, with one of concrete phosphoric acid, are to be strongly heated in a crucible; this last disappears entirely, and instead, the metal is found in part oxydated, and in part combined with phosphorus; for the quantity of metal being greater than what is necessary to absorb all the oxygen contained in the acid; a part of this metal acts on the oxygen of the acid, whilst the other acts on the phosphorus; and hence an oxyd and a metallic phosphorus arise. The phosphoric acid combines easily with most metallic oxyds, with which it forms salts fusible in the fire, very little soluble in water, but soluble in the phosphoric acid, some of which are crystallizable on cooling, after fusion. The greater part heated with charcoal afford phosphorus or metallic phosphures.

## Silver.

The phosphoric acid precipitates silver from its nitric solution, and unites with the oxyd, forming the phosphat of silver. This is thick, heavy, and of a white colour, melts by a great heat into a greenish or olive-coloured enamel, according as it is more or less heated. This phosphat is insoluble in water, but dissolves in an excess of phosphoric acid. Treated with charcoal in a retort, it affords a little phosphorus, and is in great part reduced to a phosphure of silver, containing from 0,15 to 0,20 of phosphorus.

## Copper.

This acid is not decomposed by copper, but on remaining some time upon this metal, it assists its oxydation either by the water or air, and forms phosphat of copper, which is very little soluble. It is immediately obtained by pouring solutions of alkaline phosphats into most of the mineral salts of copper; a double decomposition takes place; the phosphoric acid unites with the oxyd of copper, and forms a precipitate of greenish coppery phosphat, nearly insoluble. Its properties have not been examin-

ed; heated however with charcoal in a crucible, it affords a brilliant grey phosphure of copper.

If acid combines very slowly with iron, it however at Iron. fast oxydates it, and forms a phosphat of iron; which is an insoluble salt. It may be prepared by pouring solutions of alkaline phosphats into those of sulphat, nitrat, or muriat of iron, when a double exchange takes place. The precipitate or phosphat is white. It is easily reduced by red hot charcoal into a metallic phosphure. As urine is found to act upon iron, this metal ought not to be exposed to places where this fluid is constantly met with, as the phosphoric acid it contains corrodes it.

It only attacks lead very slowly, and converts it by de- Lead. grees into an insoluble white phosphat. Alkaline phosphats likewise on being mixed with nitrat of lead, or with the muriat by heat, form it. This phosphat of lead, which appears to become soluble by excess of phosphoric acid, and even by other acids, is fusible in the fire, and on cooling forms regular polyedrons. It is decomposed by red hot charcoal, which converts it into phosphorus and lead, whilst itself becomes carbonic acid. The sulphuric, nitric, and muriatic acids decompose it in the moist way, by which the acid is separated; alkaline carbonats also decompose it.

It has scarcely any action upon tin in a liquid form, Tin. and in the cold. Soluble phosphats poured into muriat of tin afford a precipitate of phosphat of tin. Vitreous phosphoric acid, treated with half it's weight of tin; is decomposed; on one side, vitrified phosphat of tin is formed; on the other, phosphure of tin. Pelletier first made this known.

This acid diluted forms with zinc a phosphat in the Zinc. form of a white powder; hydrogen gas is disengaged from the water. It is also obtained as a white precipitate, when the phosphats of potash, soda, or ammonia are



added to a solution of the sulphat, nitrat, or muriat of zinc. This metal strongly heated with vitreous phosphoric acid, reduces a portion of it to phosphorus, and forms with it a phosphure of zinc.

**Quicksilver.** This acid, although it has no effect on quicksilver, unites to it's oxyd. This union however is not well accomplished but by precipitating nitrat of mercury by a solution of the alkaline phosphat, when an insoluble white precipitate of mercurial phosphat is formed. Most animal fluids afford this salt mixed with mild muriat of mercury, by means of nitrat of mercury. This phosphat is luminous and phosphorescent when rubbed in the dark; exposed to heat, especially with a little charcoal, phosphorus is produced.

**Manganese.** It does not act on manganese, and only dissolves it's oxyds with difficulty; the phosphat of manganese is obtained by pouring a solution of alkaline phosphat into that of nitrat or muriat of manganese.

**Nickel.** It has only a weak attraction for the oxyd of nickel; the solution is scarcely greenish, and affords no crystals.

**Cobalt.** It dissolves the oxyd of cobalt, and forms a reddish liquor which becomes turbid, and is deposited when the acid is saturated.

**Uran.** United to the oxyd of uran, it forms flakes of a yellowish white colour, very little soluble in water.

**Titan** It precipitates the oxyd of titan from acids, in the form of a white powder.

Such is the account that Fourcroy gives of the action of this acid upon saline bodies and metallic substances, by which it appears how weakly it affects metals, on account of the strong adherence of their principles. By exposing them however to a great heat, towards the end of the process, phosphorated hydrogenous gas is extricated. Metallic phosphats are heavy and decomposable by several acids. If the vitreous acid be strongly heated with



metals, the last by depriving it of a portion of its oxygen form two combinations at the same time, viz. phosphates and metallic phosphures.

Some of the earthy and alkaline phosphates exist in abundance in fossils, a greater number in animal fluids, several in vegetable matters, but the greatest quantity is the creation of art alone. Some of them were known towards the middle of the 18th century, for before this time they had been confounded with muriats. They are formed by the phosphoric acid, and are kept in close bottles. They are in general crystallizable, their flavour often saline, mild and fresh, very much like muriats, and several chemists regard them as the heaviest of salts. Light has no action upon them; all are fixed in the fire, easily fused to a glass, sometimes transparent, sometimes opaque; most emit on perfect fusion, or even before any fusion, a light, a splendour or phosphoric flame, particularly before the blow pipe upon charcoal, although in general this character is weak; by this means, the greater number only lose their water during fusion and preserve their saline nature. Oxygen or azot has no effect upon them, hence whatever arises from the contact of the air is from the water. Some undergo no change in it, others effloresce and lose their crystalline form, whilst others attract a slight humidity. Although the phosphoric acid is decomposed by hydrogen and carbon heated, or red hot, and gives up its oxygen, converting them into water and carbonic acid, yet these two substances have no effect upon phosphates at any temperature; the only exception is perhaps the phosphate of ammonia, and this is only apparent, for it has lost its ammonia when this takes place. Phosphorus, sulphur, and the metals have no effect upon phosphates, and if metals are in some degree changed by these salts, it is to be attributed to their water of crystallization, or solution. These phosphates are

Properties  
of earthy  
and alkaline  
phosphates.

either very soluble or almost entirely insoluble, most of the first are so, more from the heat, and crystallize on cooling; the second are always in powder, although nature sometimes presents them crystallized; hence the secret of their solution. All metallic oxyds combine with phosphats by heat, and produce coloured vitrified compounds of different colours, used in the arts; these are produced either before the blowpipe or in a crucible. Some acids have a remarkable effect upon them; the sulphuric decomposes the greatest number, and only a part of those capable of being acidules; the phosphoric unites with some, and converts them into acidulous phosphats; the nitric decomposes nearly all, and the solution, always acid, contains nitrats and phosphoric acid, or nitrats and acidulous phosphat with respect to those it only decomposes in part; the same with the muriatic; the sulphurous, nitrous, phosphorous, fluoric, boracic, and carbonic have no effect. It is by their decomposition, by the sulphuric, nitric, or muriatic acids, that their exact analysis and proportion of their parts is known; for as the phosphoric acid is easily known when separated, the kind of salt is easily discovered. Earths capable of vitrification easily unite with those salts by fusion into various kinds of glass, or enamels more or less opaque, by forming triple combinations; other bases are differently affected by phosphats, according to the nature and peculiar attractions they have to the phosphoric acid. Such is the account of this acid and its effects on bodies as given by Fourcroy.

The phosphoric acid used previous to the distinction between phosphoric and phosphorous acids.

On examining authors who have published their experiments on the different combinations of the phosphoric acid with other substances, it is often difficult to know whether they are speaking of phosphats or phosphites, as they have rarely explained what kind of acid they made use of, and the manner how obtained it; from this arises

the different results chemists have met with in their experiments. On describing therefore the action of this acid on other bodies, and in giving an account of its history, that *acid of phosphorus* is supposed to have been used that was employed before any distinction was made between the phosphoric and phosphorous acids, or at least before it was attended to by the generality of chemists.

We are informed, that when this acid is melted with gold leaf a purple scoria is produced, it changes red precipitate to yellow and white, and by long digestion to black; it completely dissolves white arsenic, but not the regulus. It dissolves zinc perfectly; the solution exhales a fetid smell, but yields no crystals on evaporation; a gummy mass remains, which, on fusion, becomes a transparent glass. It dissolves the regulus of antimony, and more readily its precipitate by fixed alkali, and the combinations with this metallic substance are also easily vitrescible by heat. It attacks bismuth and its calx. With regulus of manganese it forms a red solution, and the same with its calx, which however becomes white on exposure to the air. When this acid is treated with metallic substances in the *dry way*, its action is more powerful, and with tin, lead, and especially iron and zinc, it forms phosphorus. With respect to its effects on metallic solutions, it precipitates gold from its solution in its metallic state, and silver likewise. A solution of mercury yields a copious white precipitate, which, according to Margraaf, redissolves on standing. With iron, the phosphoric acid, after having easily dissolved it, forms, when in a large proportion, a crystallizable salt; and with a less proportion, a compound insoluble in water, but soluble in acids; the solution is accompanied with effervescence and disengagement of hydrogen gas. When the solution of iron in this acid is diluted considerably with water, even although the acid abounds, a precipitate falls

either immediately, or after some exposure to the air. This precipitate is of a blueish colour, is insoluble in water, but is changed by it to a green. This solution of iron when precipitated by a fixed alkali gives a white powder, which afterward becomes green; by the prussian alkali, a blue powder; and by infusion of galls a black sediment. These precipitates are not mere calces of iron, but contain some portion of the acid; particularly the powder that is deposited merely by dilution with water, or by exposure to the air, is a perfect compound of phosphoric acid and iron. According to Westrumb it has a stronger affinity to zinc than to any other metallic substance.

The phosphoric acid has when concentrated a strong action on oils; it at first discolours them, and at length blackens or carbonizes them; producing heat and a strong smell, like that of a mixture of ether and oil of turpentine; but, according to Ker, it does not form a true soap, which property, according to Cornette, is peculiar to the vitriolic acid. It has most effect on *essential oils*, less on *drying oils*, and least of all on fat oils. In spirit of wine it is said by some to be soluble, by others not. It's action on animal and vegetable substances is more or less lively, according to it's degree of concentration, and deprived of all humidity that it has received by deliquescence, it is still capable of destroying in time their texture and colour.

Priestley attempted to convert the acid into a state of gas, but he found that at the common temperature of the atmosphere it was recondensed, without having undergone any change. In a concrete crystalline form, de Trudaine found, that it only melted in the focus of a burning-glass, when placed on a piece of charcoal, which Macquer attributes to the facility with which light traverses transparent bodies. Berniard has announced, from



the observation of Cornus, that phosphoric glass has the property of being the most electric of all known glasses.

*Mistaken for other acids.*—Boyle appears to have looked upon the phosphoric acid as being the muriatic, and Henkel and Stahl considered it as a modification of the muriatic acid brought about by phlogiston. This opinion was founded on the circumstance, that urine, from which phosphorus was obtained, contained both these substances in great abundance; and when common salt was placed upon burning coals, a vivid blueish flame arose, similar to that from phosphorus: this hypothesis has been abandoned since the experiments of Margraaf, who endeavoured by all possible means to form the combination, but without success; he, however, out of respect for Stahl's opinion, seems not entirely to have denied, that it might be of the nature of the muriatic acid, but not in its pure state. He thought it perhaps might be the same acid, but united in a peculiar way to a very tender glacial earth. Other writers, as Hoffmann, Wenzel, Vogel, and Pöerner were of opinion, that the phosphoric acid is composed of the vitriolic and muriatic acids; but as these two acids could not be produced by the decomposition of the phosphoric acid, nor the phosphoric acid produced by the composition of them, it began to be considered as a peculiar acid. Bosc d'Antic, as well as Sage, thought it contained the matter of the fluor, aerial, and urinous acids; even Sage carried it still farther, and raised this acid to the honour of the original and elementary acid. He thought he could trace it in fixed alkalis and in metallic calces, and considered it as the sole principle of vitrification. This chemist, however, wanted facts to support his assertions. Macquer attributes to it the nature of sedative salt and white arsenic: thus, he says, that sedative salt, in many cases, takes place of an acid, without openly showing acid properties; it unites with alkalis, satu-

Phosphorus  
taken for  
other acids.



rates them, and changes them into neutral salts. In the fire, it is fixed, and melts, like the phosphoric acid, into a glacial matter; and lastly, it precipitates, like it, neutral salts from their mixtures. With respect to arsenic, it is not so fixed as the phosphoric acid, and only decomposes salt petre; but it is as much disposed to vitrify as this acid, and as to its smell, it perfectly resembles that of phosphorus. With respect, however, to its power of promoting vitrification, Ker observes, it is by no means peculiar to these acids and alkalis. The marine acid exerts it very conspicuously upon clay, in those potteries where the glazing is given by marine salt volatilized by heat, in which operation the effect is greater than the alkali alone of the salt could produce; whilst from Pott's experiments, the greater fusibility of gypsum, when mixed with other earths, than pure calcareous earth, shows the vitrifiable powers of the vitriolic acid; and this power is still more conspicuous in the acid of fluor; hence the idea of Macquer is likewise false.

Composition  
of the  
acids.

From the processes of obtaining the phosphoric acid from phosphorus, it appears, that it consists of phosphorus united with the pure air of the atmosphere, which it absorbs, and by which its weight is considerably augmented. If the operation be performed slowly, not only the pure part of the atmospheric air is absorbed, but also a sufficient quantity of moisture is attracted to produce a liquid acid. If, however, the operation be performed in a vessel filled with pure air, confined by mercury, and particularly placed in a hotter temperature, white fumes will arise, and light flocks will float in the air, and attach themselves to the side of the vessel. This is a concrete acid, which soon attracts moisture when exposed to the atmosphere and deliquesces.

Hence the phosphoric acid is composed like all the

other acids, *i. e.* of a radical or peculiar acidifiable basis; and vital air, which is the common acidifying principle. Scheele, having enclosed a piece of phosphorus in a phial the capacity of which equalled seven ounces of water, filled with vital air, and having applied some heat to it by means of a candle, found that the external air pressed so strongly on the stopper, that he was obliged to put it under water. Another time, the same chemist observed, that nine grains of phosphorus placed in a glass vessel, sealed hermetically, the capacity of which was equal to 30 ounces of water, had diminished the common air during the combustion about 9 oz. by measure. According to Kirwan, it is a circumstance worthy of great attention, that the air is much more diminished by phosphorus than by any other combustible substance; but Morveau thinks that this difference cannot be attributed to the greater degree of heat produced, since this heat is itself the effect of a greater diminution or decomposition of vital air; but he thinks with Scheele, that the reason of the absorption being here more considerable, arises from the combustion not being disturbed, as in other similar experiments, by the vapours dilated by the heat, and which surround the flame.

Great diminution of the air, and great heat from the produce of the acid.

According to the experiments of Lavoisier, confirmed by those of de la Place, 45 grains of phosphorus absorbed, on burning 65, 62 grains of vital air, and in the formation of the phosphoric acid, one part of the phosphorus combines with  $1 \frac{4}{9}$  of vital air. These learned academicians observed, that the heat, disengaged by the vital air, when it was absorbed by phosphorus, was nearly  $2 \frac{1}{2}$  greater than when it was changed into fixed air.

It remains now to know what is the basis which phosphorus furnishes in the formation of the acid, to the acidifying principle. According to the principles of

The radical  
and acidify-  
ing princi-  
ple.

Stahl, when reconciled to the most modern discoveries, it is a peculiar substance of it's own kind, which, by it's union with phlogiston, constitutes phosphorus. Lavoisier, on the contrary, has laid it down to be the phosphorus itself, which, uniting with the oxygen of the air forms the acid, which is now the generally received opinion.

Phosphoric  
acid formed  
in all the  
kingdoms.

The phosphoric acid was formerly thought peculiar to animal substances; but Margraaf found it also in the vegetable kingdom, and was able to obtain phosphorus by distilling wheat, mustard seed, and other vegetable matters; and Gahn discovered it in the ore of lead; hence it's existence has been found in all the three kingdoms. With respect to the *anima*', there is, perhaps, no part of animal bodies free from it. It was observed particularly to exist in urine, partly united with soda, partly with volatile alkali, and partly with calcareous earth. Scheele and Berthollet found, that it also existed in this animal fluid, in a disengaged state, and that it betrays it's presence in recent urine by it's effect on the colour of litmus. Homberg found it in blood. It is found in large quantity in bone, which Gahn discovered in 1769. Scheele found it in stags' horns; Maret, in flesh; and Proust found the fresh decoction of flesh to redden turnsole from this acid. Crell found it in ox suet and human fat; Hankewitz, in human excrements; Leiden, Henschen and Andrea, in old cheese; Berthollet, in sweat; Hohenholz, in crabs eyes; Marquis de Bouillon, in fish bones. Crell has extracted it from beef suet and human fat; Macquer and Struve, from the gastric juice; Henschel saw it in the sweat; Berniard got it from egg shells; and Hatchett, from other shells of different kinds. In the *vegetable* kingdom, Albinus, Lauth, Hoffmann, and Pott, had long ago mentioned it's existence; and Margraaf, as before observed, in mustard

feed ; Meyer found it in the green resinous part of leaves, to which he attributes the colour ; and Berthollet, in those plants which yield volatile alkali, where he thinks it chiefly resides. Haffenfratz obtained it from potatoes, agaric, foot, and woods of different kinds, and from marshy plants, charcoal and fossil coal. Westrumb likewise obtained it from charcoal in the following manner. He phlogisticated a fixed alkali by melting it with charcoal, to which he added some sal ammoniac. The lixivium of this alkali he saturated with vitriolic acid, and added to it a solution of iron in marine acid, upon which a precipitate was formed ; consisting of phosphoric acid and iron. In the *mineral* kingdom, after Gahn had found it in lead, Proust announced that it would be in other metallic bodies, and it was found in the marshy ores of iron by Meyer, Stettin and Bergman, forming with the iron the compound called siderite, to which has been attributed the cold-short quality of iron ; by Klaproth, in a species of beril called by Werner apatit, in which the acid is united with calcareous earth. Haffenfratz attributes the phosphoric acid found in marshy ores of iron to the aquatic plants and animals, in which his experiments have proved the existence of that acid ; and he supposes these marshy ores to be of modern date, and formed by deposition of waters, and consequently replete with vegetable and animal matter ; but he never found this acid in those ores which lie in the more ancient strata, as the magnetic, black, pyritous, hepatic, and spathose ; yet he discovered traces of it in cast iron, even in that which had been made from these latter ores ; and this he attributes to the charcoal employed in the fusion. This acid is likewise an ingredient in the formation of mountains. Thus Bowles has described a large native mass of a phosphoric stone, of which many hills are composed, near Lagrofo, a village in Estremadura, a



province of Spain. He informs us, that this stone is whitish, and without taste, and that it gives a blue flame without smell, when thrown on hot coals. Proust further describes this stone as dense, not hard enough to strike fire with steel, and says it appears in strata, which always lie horizontally upon quartz. When this stone is scattered upon burning coals it does not decrepitate, but burns with a beautiful green light, which lasts a considerable time; and in this respect, it is not unlike the fluor spar, the light of which, however, is more blue and less durable. With the vitriolic acid it forms a selenite, while the remaining liquor is the phosphoric acid, similar to that obtained by dissolving bones in the vitriolic acid. Hence the stone is a calcareous phosphat.

*It's origin.* As the phosphoric acid is found in each of the three kingdoms, the great question is to know from which it derives it's origin. Margraaf having discovered it in vegetables, thought it was formed there, and thence conveyed into animals. Ker is of opinion, that as it exists more copiously in animals than in vegetables, and as acidification consists in the union of air with some inflammable matter, which process is manifestly carried on in the lungs of animals, where, by respiration, pure air is continually absorbed, and combined with the most disengaged inflammable matter it can find in the blood; it is not improbable, that it may be formed also in the bodies of animals, and that as large quantities are continually carried off from them in their excretions, he conjectures, it's formation and subsequent excretion are a mode employed by nature to carry off the phlogistic matter, as soon as it comes to a proper degree of disengagement, which is continually evolved in the animal process, and which, if not combined, would cause immediate death. It would appear, that the phosphoric acid is formed both by vegetables and animals, which are only degrees of



the same organization, and that the more animalized a body is, the larger is the quantity of this acid it contains; its quantity in animals is considerable, where it is not only combined with soda, lime and ammonia, but is also in a disengaged state, as it is found in flesh and in urine.

*History of the acid of phosphorus.* This acid was unknown to the ancients. When it was first discovered, and a long time afterwards, having been generally procured from urine, it was called by some chemists, the *acid of urine*. But since it has been found to exist in other substances, and more particularly in bones; and another acid, which possesses different properties, was equally found in urine; the name of the acid of urine has given way to that of the phosphoric acid, particularly since it was obtained from phosphorus by combustion. The phosphoric acid appears to have been discovered the latter end of the seventeenth century. Boyle, on examining the clear liquor which the flowers of phosphorus afforded, found by the taste that it was acid; it changed the sirup of violets to a fine carnation colour, and dissolved the filings of copper; and he compared it to the spirit of sea salt. Frobenius, on applying heat to some phosphorus, obtained from it a large quantity of very white flowers, and having admitted air to them, they melted into a clammy liquor, resembling gum water; by heat, they became hard and transparent. He gave to these the name of vitrum molle; being exposed to a strong heat they became brittle like glass. He informs us he procured an acid from them. Hankevitz having deflagrated some phosphorus, obtained a quantity of flowers from it, and found they had gained 2 drachms in weight; these being placed in a cool situation became dissolved into a liquid that had gained still more in weight. He informs us likewise, that it contained an acid salt,

Slare.

more fixed in the fire than any salt then known, and had other properties peculiar to itself. Slare found, that after the deflagration of phosphorus no ashes remained, but there was instead a little moisture that tasted subacid, resembling a weak oleum fulphuris per campanam. It set his teeth on edge, and dissolved iron. He tells us, that a piece of phosphorus when resolved into this liquor, weighed at least thrice it's original weight. It appears, therefore, that so early as between the years 1679 and 1698, when Boyle and Slare published their papers, an acid had been discovered to be produced by the spontaneous and artificial combustion of phosphorus; that it had even received an increase of weight during the change, and that it was to be obtained in a concrete form; but it was unknown to be a peculiar acid, since known by the name of the phosphoric, and consequently none of it's properties had been examined. Even at the time of Hellot, in 1737, it was supposed, that the deliquescence of phosphorus was only a real solution brought about by the tenuity of the aqueous particles, in a state of vapour, and because it's inflammable principle was dissipated. The chemist who first gave any satisfactory account of this acid, and who described it's properties, was Margraaf, about the year 1743 (a detail of whose experiments will be given hereafter).

It has been already said, that there are three methods of obtaining the phosphoric acid, viz. by deflagration, slow combustion, or by affinity in the humid way.

First method  
of obtaining  
the acid.

*The deflagration of phosphorus* is a lively and rapid combustion; and if this substance be placed in a vessel so that it may be exposed, either naturally or artificially, to a degree of heat of about 24 degrees of Reaumur, it enflames with a kind of explosion; the bottom of the vessel is found covered over with a flaky white matter, the weight of which is more than double that of the phosphorus itself,

which very readily and powerfully attracts humidity from the air, and is at last converted into an acid fluid, of the consistence of a thin oil; and this is the phosphoric acid. Without waiting, however, for the deliquescence, a certain quantity of water being poured upon this residuum soon dissolves it, except a portion of yellowish orange matter, which is phosphorus not decomposed, and which remains on the filter. This operation by deflagration has been described by Margraaf, who observed, as well as Hankevitz and Slare, that the product had increased in weight; and it was upon the ley of this residuum, concentrated by distillation of the phlegm, that he made his first attempt to investigate its combinations. To obtain the acid, he deflagrated the phosphorus in a glass mortar, which he placed upon a glass or porcelain plate, gently heating the last at the bottom: he likewise placed it under a cucurbit covered with an alembic, making use of a receiver. By this means, from one ounce of phosphorus he obtained, by deflagration, one ounce and  $\frac{1}{8}$  of a drachm of the acid; and the acid thus prepared, according to Margraaf's process, has been called the *phosphoric acid by deflagration*. (*Acidum phosphori per deflagrationem*).

Lavoisier tells us, that the method he used to procure Lavoisier. the phosphoric acid for his experiments was, to burn the phosphorus under a glass bell inverted in mercury, by means of a burning lens; a great abundance of white flocks attach themselves to the sides of the vessel, which are the concrete acid, and are almost immediately dissolved into a fluid state on coming into contact with the air; the product is a very concentrated and heavy acid, without odour, and has the oily appearance of the concentrated vitriolic acid. If the acid is wanted of less strength, this chemist has given a more easy and expeditious method: the phosphorus is deflagrated under

large glass bells, into which a little distilled water has been poured: when the vapours arising from the first combustion are dissipated, a fresh quantity of phosphorus is introduced under the vessel, which is to be deflagrated like the first, and the process is thus to be continued for several days, until a sufficient quantity of phosphoric acid is obtained; but although this process has the advantage of affording the acid in a short time, yet it holds in solution a pretty considerable quantity of phosphorus undecomposed, which alters it's properties.

Wolfe and  
Feulter.

Wolfe and Pelletier invented a process for obtaining this acid by combustion, by melting this substance under water, and by passing a current of pure air through it.

Second me-  
thod.

2d. *Phosphoric acid* is obtained by a more complete conversion of the phosphorus, on submitting the latter substance to, a *slow combustion*; for if phosphorus be exposed during some weeks to the ordinary temperature of the atmosphere, even in the winter, it undergoes a slow combustion, and is gradually changed into a liquid acid. For this purpose, it is usual to put small pieces of phosphorus on the inclined side of a glass funnel, through which the liquor, which is formed, drops into the bottle placed to receive it.

Boyle.

Boyle, having placed about 3 grains of phosphorus in a glass funnel, which he set in the window, it continued to shine for fifteen days, and there was left behind a liquor, which, on being weighed, he found to have increased to three times it's weight; but he was ignorant, as before observed, either of it's being a peculiar acid, or of the cause of the increased weight.

Stare.

Stare having exposed half a grain of this substance in the open air, it continued to flame seven or eight days, and when it was extinguished no ashes or recrements remained behind except an acid moisture, of which he knew nothing.



Sage recommends to cover the orifice of the funnel into Sage. which the phosphorus is put with a cucurbit ; and as the end of the funnel enters a bottle into which the acid falls, a small glass tube should be placed in the middle of the funnel to give vent to the air of the bottle, which is displaced by the acid ; for without these precautions, the phosphorus would inflame with explosion in the apparatus, when the thermometer is at  $15^{\circ}$  above the freezing point. The inflammation may take place even at a very inferior degree, when there is a certain quantity of phosphorus, or if the pieces of phosphorus touch, or are too near each other, which, we are informed, happened once even in a cellar belonging to the academy of Dijon.

By slow combustion, Morveau, Maret, and Durande, obtained from one ounce of phosphorus three of the acid, and when thus prepared, it has been called *phosphoric acid by deliquescence*, (*acidum phosphori per deliquium.*) It is without odour or colour, of the appearance of concentrated vitriolic acid ; but it still retains some undecomposed phosphorus, which is observable on being exposed to the fire, by it's very acid, white vapours, and small luminous explosions ; and although this portion of phosphorus is very small, yet it may lead to error on making any delicate experiments ; but it is easy to deprive the acid of it by distilling it upon spirit of wine, which does not volatilize it, and which takes hold of the phosphorus.

According to Morveau, the name of *acid by deliquescence* is very improper ; for it is not the water that decomposes the phosphorus, and converts it to the state of acid ; it is only attracted by the acid perfectly formed, or in proportion as it is formed, by a real combustion, which only differs from the preceding by being much more slow, as is evident from the odour which the phosphorus does not cease to exhale, and the light it disperses during



the whole process, and which, although weak, is however sensible in the dark. The air is therefore the only agent of the decomposition. The acid procured by means of Sage's method by water may be deprived of that fluid, and brought to a thick, or even a glacial consistence, by evaporation and distillation.

3d method. 3. With respect to the third method, or that by affinity, it is now well known, that phosphorus as well as sulphur is susceptible of passing into an acid state by means of *affinities in the humid way*, without any inflammation either vivid or slow; but, as Morveau has expressed it, by a species of cold combustion; thus it is easily obtained by means of the nitrous acid.

Scheele. Scheele was the first who obtained the phosphoric acid by the nitrous acid; it was afterwards procured by Chap-  
Lavoisier. tal; but Lavoisier has given a more convenient form of process, of which the following is an account: He took a tubulated retort containing six or seven pints, into which he poured two pounds of nitrous acid, of a specific gravity to water as 129895 to 100000, and placed it on a sand bath; to this he adapted a receiver; he then applied by degrees a heat until the liquor had acquired about  $45^{\circ}$ , and put into the retort a piece of phosphorus of 10 or 12 grains in weight, which immediately fell to the bottom of the liquor, melted like wax, and produced a very lively effervescence: when the first piece was dissolved he put a second, then a third in, and repeated this by slow successions, until he had combined all the phosphorus he wished to dissolve with the acid. The quantity was 2 oz. 6 or 7 drachms. The solution in the beginning was made with great ease, so that he was obliged to manage the fire lest the effervescence should be too great; but towards the end the action of the acid upon the phosphorus became by degrees slower, and it became necessary, in order to support the effervescence and the solution, to

raise the heat to such a degree as to exceed that of boiling water. Whilst only a drachm or one drachm and a half of phosphorus had been dissolved, the liquor underwent no change, except receiving a yellow tinge like aqua regia; afterward it became green; at the same time very thick, red and turbid vapours arose, which were only nitrous air and very fuming nitrous acid. These vapours, which formed a thick cloud, appeared to fall and run from the orifice of the retort, like a liquid, and continued to pass all the time of the solution of the phosphorus. The products, however, which passed during the distillation being collected, and which continued 17 or 18 hours, were as follows: at first 2 drachms 24 grains of a very weak nitrous acid, nearly white, came over, and the vapours which arose from the liquor in the retort during the time this acid passed over were scarcely coloured; but as the vapours became more intense, the acid which arose was more yellow, and began to fume; the second portion which was set apart weighed 3 oz. 50 grains; this second portion was followed by a nitrous acid of a deep green yellowish colour, and more fuming than the preceding; it weighed 6 oz. 2 drachms: the nitrous acid obtained afterwards was rather less green, and not so fuming, it weighed 5 oz. 5  $\frac{1}{2}$  drachms; and toward the end of the passage of this acid, the intensity of the red vapours considerably diminished, and nothing was now obtained but white nitrous acid scarcely fuming; this last portion weighed 4 oz. 2 drachms, 6 grains. The liquor in the retort was now entirely saturated with phosphorus, and the portions added would not dissolve, although the heat was greatly increased and long continued. Having taken off the vessels, there remained in the retort 13 oz. 4 drachms of a somewhat yellowish liquor, of an oily consistence, almost like concentrated vitriolic acid or oil of vitriol, which had still a little of the odour of nitrous

acid. To send off the last remains of volatile acid it might contain, it was put into a glass retort clothed with earth, and exposed to the graduated heat of a reverberatory furnace. At first a weak and light nitrous acid came over, which became more and more phlegmatic; then nothing but a phlegm of a red colour, somewhat bitter, that was no longer acid, and which did not effervesce with alkalis. Having still increased the heat a little, even so as slightly to redden the bars on which the retort reposed, very penetrating white vapours began to pass over, which were collected in the receiver, and which proved to be real *phosphoric* acid; in a state, however, half volatile. The operation being thought now complete, the vessels were left to cool; but on attempting to take out the liquor remaining in the retort, the greatest part was observed to have become as thick as turpentine, and stuck to the interior of the vessel, from which it was impossible to pour it but by diluting it with distilled water; and this prevented it's being weighed with exactness. The quantity of phosphoric acid obtained from 2 oz. 6 drachms of phosphorus by two pounds of nitrous acid may therefore be valued at eight or nine ounces; supposing the process not carried to the point of reducing the acid to the consistence of thick turpentine, but only to that of a somewhat thick sirup. Such is the process which Lavoisier made use of to obtain the phosphoric acid, and in which the remaining two drachms of phosphorus were supposed to have evaporated.

Bergman.

Other acids are said to produce the same effect; thus Bergman affirms, that if a piece of phosphorus be put into some arsenical acid, it's whole surface soon becomes black, from the portion of arsenic that adheres to it in a reduced state: he does not, however, speak of the state of the liquor, but it appears to pass in some part to the state of an acid.

The same chemist, as well as Scheele, informs us, that Scheele. the dephlogisticated muriatic acid immediately converted some phosphorus into a white smoke; but Morveau contradicts this assertion by his own experiments, saying, that the most concentrated dephlogisticated muriatic acid in a liquid state, even that taken under a concrete state, in the manner of Berthollet, has no action upon phosphorus at a medium temperature, nor even at  $15^{\circ}$  above the freezing point. Berthollet accounts for the difference between these chemists, by observing, that no action takes place between these substances without the assistance of *light*, but that when a piece of phosphorus is added to dephlogisticated marine acid and the mixture exposed to light, it will acquire the properties of reddening the blue juices of vegetables, and of precipitating lime water, and forming a calcareous phosphoric salt; and hence it appears that the phosphorus imbibes the pure air of the dephlogisticated acid, and is changed into phosphoric acid; and indeed Morveau appears to admit the solution in the *Encycl. Méth. art. acide mur. dephlogist.* where he says, this acid instantly decomposes phosphorus, disengages a white smoke, takes hold of its phlogiston, and returns into a state of common aeriform muriatic acid. It is easy to account for the conversion of phosphorus into the acid by means of the affinities. The acids give up their oxygen to the phosphorus, and hence it takes its acid state; and the same may be effected, as Sage has shown, by adding solutions of copper, silver, and other metals, to phosphorus; the metals are precipitated in their metallic state, and the phosphorus becomes an acid.

4. A fourth method of obtaining the phosphoric acid 4th method. is, by separating it from the saline or earthy bodies with which it is united. It is now well known that the phosphoric acid is found united in urine to volatile alkali for



Rouelle.

it's basis, forming the native phosphat of urine or fusible salt; but as it is present in urine with one or two fixed neutral salts, the phosphoric acid cannot be procured from it by heat in that state. When, however, this native phosphat is pure, the volatile alkali may be expelled from it by heat, by which means the phosphoric acid, being fixed, remains behind. Thus, according to Rouelle, when the fusible salt is deprived of every other neutral salt, and the liquor is put into a porcelain crucible, or any other proper evaporating vessel, if it be placed in an open fire or sand bath, and the liquor be then evaporated with caution, raising the heat towards the end of the process, so as to melt the phosphoric acid, it will be obtained in as transparent a state as the most perfect and beautiful crystal. The phosphoric acid thus obtained has been called the *acid basis of native salt*; it is produced in a glacial state from the heat employed.

Hermbs-  
tadt.

It was likewise proposed to procure the phosphoric acid from another salt contained in urine; thus Hermbsadt advises to digest *Proust's perlated salt* in vitriolic acid, which uniting with the mineral alkali, and by it's union forming a salt capable of crystallization, leaves the phosphoric acid disengaged. The acid thus separated may be further purified by heat from any adhering vitriolic acid.

All chemists, however, agreed that the acid extracted from phosphorus was much more pure, and hence that by combustion was called by Proust, *acide phosphorique par excellence*.

At the article *hard parts*, an account was given of several methods of procuring this acid from bones; from which it appeared, that on employing the vitriolic acid, the principle fault was the imperfect separation of the calcareous earth; of which although the greater part unites with the vitriolic acid, and forms an insoluble selenite, yet enough remains in the acid lixivium to yield



an earthy sediment upon evaporation, and to give some degree of opacity and of insolubility to the vitreous acid prepared by this method. The presence of the calcareous earth is proved by melting the vitreous acid with a sufficient quantity of fixed alkalis, and lixiviating the melted mass with water, upon which the calcareous earth will appear undissolved. In order to purify this acid, therefore, Rouelle recommended a method, founded on it's property of being insoluble in spirit of wine. He broke the vitreous acid into small pieces, and by addition of a little water reduced it to a gelatinous liquor, which he decanted clear from the earthy matter, and mixed with it 12 parts of spirit of wine. Next day the phosphoric acid was found at the bottom of the mixture, of the consistence of resin of jalap recently prepared. By exposing this acid to heat in a crucible, the moisture and any vitriolic acid adhering to some remaining portion of selenite were dissipated, and by urging the heat, a glass transparent as crystal was formed. Weigleb made use of another method, as observed at the art. *bones*; but a great improvement, according to Ker, has been made on the depuration of the phosphoric acid by Bonvoisin. Having found that evaporation and filtration were insufficient to separate all the earth adhering to the acid of bones, prepared by the vitriolic acid as described, he added a caustic volatile alkali, and obtained a copious precipitate, and when he could separate no more by the caustic volatile alkali, he observed, that upon adding the same precipitate in a mild state, some further precipitation ensued. He suspected that the whole of the precipitates were *not selenite*, as has been generally supposed, and he found by experiment, that the precipitate formed by caustic ammonia was a *phosphoric salt with a calcareous basis*, and that the precipitate formed afterward by mild ammonia was a *calcareous earth*. He concludes, therefore, that after the

selenite has been precipitated in the common process, a portion of calcareous earth remains combined with the phosphoric acid, forming the phosphoric salt with basis of calcareous earth; which, although little soluble in water, is readily dissolved in the acid of bones, or in other acids, as he found was the case. To separate therefore the calcareous earth, the acid must be saturated with an alkali, and the volatile is preferable, because it may afterwards be expelled from the phosphoric acid by heat; and the mild alkali is preferable to the caustic, because the former decomposes the phosphoric salt of lime, so that the whole of the acid remains in the lixivium, while the earth only is precipitated, whereas the caustic alkali would precipitate the entire salt, being only held in solution by the superfluous acid. Bonvoisin continued the process, by evaporating the lixivium saturated with volatile alkali, and he obtained a crystallized ammoniacal salt, which he melted in a silver vessel, the acid acting upon glass or earthen vessels. The acid thus prepared is a compact glass as transparent as rock crystal, is acid to the taste, soluble in water, and deliquesces on exposure to the air. It differs in some respect from the acid obtained by burning phosphorus, and is even purer, as Bonvoisin affirms, than this latter acid, which in his language is apt to be more or less phlogisticated: for the acid prepared by combustion gives more red fumes when mixed and evaporated with nitrous acid, destroys the red colour of a solution of manganese in vitriolic acid (a sign of the phlogistication), and is less disposed to crystallize when saturated with volatile alkali. The acid of bones, however, although depurated from calcareous earth by volatile alkali, is subject to one source of impurity, from which the acid obtained by combustion is free; for Scheele has proved, that bones and other solid animal matters contain some mineral alkali, from which the modes of depuration

just mentioned are, as Ker observes, perhaps incapable of freeing the acid obtained. The quantity, however, of this alkali is not very considerable, and may not affect the ordinary uses of the acid.

Likewise, according to Fourcroy, the product obtained from bones by the vitriolic acid, as well as the residue of the phosphat of ammonia decomposed by fire, does not consist of pure phosphoric acid, not affording one fifth of it's weight of phosphorus at most, but contains a certain quantity of the phosphat of soda. If this salt remains mixed with calcareous phosphat arising from a small quantity of selenite, it usually melts with the phosphat, and forms a very hard opaque glass which resists the action of all menstrua.

For a further account of obtaining this acid from bones the reader is referred to the investigation of those substances, and perhaps it might have been proper to have inserted them here.

*Vitrification of the acid.*—When the native phosphoric acid was obtained by Rouelle, it was converted into a transparent glass, and until Morveau had inserted an account of the acid itself in the Encyclop. Meth, great suspicions arose whether this substance, reduced to a state of glass in the fire, really merited the name of acid; for it was asserted, that

Vitrification of the acid.

1st. The native phosphoric acid not saturated by a basis, or that has been deprived of the ammoniacal basis by the heat of evaporation, preserves all the properties of an acid as long as it is not reduced to a glacial form; as appears from the experiments of Berthollet on the change of blue paper in recent urine, on the precipitation of calcareous phosphat which lime water produces in it, and from the observations of Rouelle on the effervescence that this acid makes with the volatile alkali added to the urine during it's evaporation.

2d. When the acid of native salt is in a state of glass, it has neither the solubility nor the flavour of acids; and according to the remarks of Proust, it would appear to belong to a general and constant law, that a simple substance enjoying every power of acidity, ought also to have the flavour, as a sign of that power. Bergman, in his dissertation on the blowpipe, looks upon the native phosphat as a salt of three parts, *i. e.* *phosphoric acid*, soda and volatile alkali, to which he adds a fat gelatinous matter, but as it is dissipated by the action of the fire, it ought not to be included in the examination of the glass which remains fixed. From this hypothesis, this glass is the *phosphoric acid* that has lost its volatile basis, which is only imperfectly saturated by the mineral alkali; and, according to this chemist, it is on account of this excess of acid that it so readily attracts humidity from the air. Proust, to whom the knowledge of that peculiar substance in urine is owing, which is foreign to the phosphorus, and which Bergman calls *acid of perlate salt* and Morveau *ouretic acid*, is of opinion that it is this substance which *saturates the phosphoric acid* in the insoluble glass of the native salt; and Bergman appears to have adopted this hypothesis in the new edition of his Dissertation on Affinities. Morveau, however, could not comprehend how one acid was able to saturate another; and how it only saturates it in a state of exsiccation, whilst in an aqueous state it lets it enjoy all the properties of a free acid. It is true, that Proust does not give this substance the name of acid, and he observes, that it turns the sirup of violets green; but he allows, or rather establishes the fact, that it performs the function of an acid, and that it acts upon alkalis as well as acids. On adopting the comparison he proposes, of this substance with the concrete boracic acid or sedative salt, it may, according to Morveau, be imagined that it passes easily of itself to the state of glass; that being in abundance, it covers and



defends the *phosphoric acid*, which is in less quantity, from the contact of all matter capable of acting upon it in the humid way; it may even be supposed, that the phosphoric acid is in part saturated with the soda, which the uretic acid always carries along with it, and that this last, as being more weak, has been obliged to give it up, or perhaps to partake of it during the vitrification; but whatever probability this comparison gives to the system of Proust, it of course must fall, if it be found, that the pure *phosphoric acid*, exempt from all uretic substance, isolated from any basis, likewise loses, at least to a certain point, the characters of an acid, on being pushed to a state of glass; and it must then be confessed, that these two effects depend on the same cause, which has not as yet been shown. For this purpose Morveau took some very pure phosphoric acid, extracted from phosphorus by a slow combustion; it was exsiccated by a gentle evaporation, and then put into a Hessian crucible in a melting furnace, taking care to reverse another crucible upon it, to prevent any foreign matter entering, and a beautiful glass was obtained. This glass, exposed several months to the external air, was not dissolved, nor even had extracted any evident moisture. Having boiled some distilled water upon it, it very sensibly reddened blue paper; having decanted this first water, what was again put upon the same acid glass no longer changed litmus, and no dissolution took place, although the glass was boiled several hours in a large quantity of water. Here then, says Morveau, is a vitriform phosphoric acid, the acid properties of which have almost totally disappeared without being marked by the substance discovered by Proust, or any saturation. This glass, however, may return to the acid state which Morveau accounts for by its passing through the state of phosphorus, by combining it with the phlogiston, and then let it inflame, the residuum being the regenerated acid,



he supposes it is the absence of the vital air which is the cause of the inertia of the phosphoric glass, and concludes, that the insolubility of the acid extracted from the salt of urine, when pushed to a glacial state, is by no means a proof of the impurity of the acid.

Discovery of  
the properties  
of phosphoric  
acid.  
Boyle.

In giving the history of the discoveries of the different properties of the phosphoric acid, it will be necessary to begin with Boyle. This celebrated chemist found, that the water in which the phosphorus, which he calls noctiluca, had been kept, to defend it from the air, had a strong piercing taste like that of sea salt, but more pungent, as if brine was mixed with spirit of salt; on evaporation, it coagulated into a substance, sometimes like a jelly, at other times like the white of egg, in consistence, which substance was easily melted by heat. If, before the coagulated matter was too far wasted by the heat, it was suffered to cool a little, it had acquired a consistence like melted resin, or rather stiff birdlime, as it would draw out into threads a foot or more in length, one of which being held to the flame of a candle, did not take fire, but melted into little globules like glass, and likewise gave out a strong smell like that of garlic; and being left all night in the air, it attracted moisture exceedingly fast, and was dissolved into a liquor almost as strong as spirit of salt. Putting this substance again over the fire as before, it appeared to become fixed, and afforded a multitude of shining explosions, with evident flashes of light. In order to examine the saline part of the noctilucal matter, he suffered a little of it to dissolve per deliquium into a clear liquor, and having dropped a little of it upon some sirup of violets, it changed it to a fine carnation colour. It dissolved some of the filings of copper without heat, and the solution was of a green and blue colour. It corroded red coral, and effervesced with dry salt of tartar, hence Boyle numbers it among the family of acid salts.

Margraaf carried his researches much farther than Boyle, and proved in opposition to the opinion of Stahl and his followers, who supposed it to be the acid of salt; that it had no connection with it, but that it was an acid *sui generis*. His experiments were made upon this acid produced from the burning of phosphorus, and likewise upon the fusible salt of urine which contains this acid in a free state; the last was dissolved in between two and three parts of distilled water; the first he calls the *phosphoric acid*; the second, the *acid liquor*; with respect to the first, he found, that mixed with a solution of gold, no turbidness was immediately produced, but afterward a few shining particles of gold fell to the bottom; distilled by a strong heat, the residuum was of a purple red colour. The acid had no effect upon fine silver filings, when strongly digested with them: with a solution of silver, after some time it became darkish and blueish, a very small portion fell down resembling black flocculi, and when distilled, the residuum looked like *luna cornea*. It seized upon the calx of quicksilver obtained by calcination, and changed it's yellowish red to white, and by strong digestion, to a black colour; but nothing was precipitated by the *oleum tartari per deliquium*. It produced an abundant white precipitate from a nitrous solution of quicksilver; this, on remaining in the cold was for the most part taken up again, and only a small black heavy powder was left. It readily dissolved the filings of copper, and the solution was green; likewise iron, and formed crystals with it. It had no effect on tin, till concentrated, it then acted somewhat upon it. The same happened with lead, but rather more; it however precipitated it of a white colour from it's solution in nitrous acid, and the precipitate was not redissolved. It perfectly dissolved white arsenic, and a blackish mass remained after distillation. It dissolved zinc very strongly, and with a stinking smell like that

arising from it's solution of tin. It united with *sal tartari*, and on evaporation, crystals were produced that did not decrepitate. It effervesced strongly, and formed longish pointed crystals with volatile alkali. With respect to the second, he found, that when strongly digested with different metals, the following were it's effects. It had no action upon gold-leaf, even by boiling, and with the addition of nitrous acid; nor upon silver; the finest copper dust was scarcely affected by it. It however dissolved iron with effervescence, and became at length turbid, glutinous, and of a somewhat blueish colour; it had but little effect upon tin and lead; it corroded zinc filings to a white powder, which, diluted with water and filtered, were precipitated by oil of tartar. Pulverized regulus of antimony was, during digestion, in part dissolved, as appeared from it's precipitation by oleum tartari; it did not affect bismuth; it gave the blue calx of cobalt a red colour. This *phosphoric salt*, however, had a much stronger action upon metallic bodies in the dry way; and as it's ammonia escapes by heat, the effects it had may be looked upon as those of the acid. Melted with pure gold it formed a purple scoria; with silver filings, an opaque scoria; with copper the scoria was greenish, it likewise gave this metal a whiter colour, and rendered it more brittle; with iron, a glassy scoria of metallic appearance, which when broken was of a greenish yellow colour; during the fusion sparks of phosphorus were constantly emitted, which Margraaf accounts for, from the acid uniting with the inflammable principle of iron; the metal was semivitrified and spongy in texture. With tin the scoria was milk white, and the metal was become foliaceous in texture, shining, and resembling zinc in it's fracture; with lead the effects were the same; phosphoric sparks were emitted from both. It dissolved the calx of quicksilver precipitated from aqua

fortis by oil of tartar; the mass was whitish, but not clear, and when dissolved in distilled water, a yellow powder fell to the bottom, which by heat was converted into quicksilver; a drop of the remaining clear water immediately made a white spot upon a clear copper-plate. It gave regulus of antimony a beautifully splendid and radiated appearance, and the scoria was somewhat opaque. Bismuth was but little changed by it. A moderate heat applied to a mixture of it with zinc produced a great deal of phosphorus, and beautiful phosphoric flames; the remainder was a gray vitrified scoria; exposed with white arsenic to a strong heat, the mass on being left in the open air deliquesced, was of a snow white colour, and when cold moderately transparent. Exposed to a red heat with sulphur, the last sublimed, whilst the salt remained unchanged in a perfectly clear fusion. With cinnabar no change of any consequence was likewise observed, it also sublimed; with manganese it became a semitransparent mass, and yellowish in some parts, but did not deliquesce; the sides of the crucible, and around the mass itself, were of a purple red; with the calx of silver, the scoria was whitish, but not clear, with a yellowish shade, and very little was reduced; with *crocus veris* a beautiful green scoria was produced, in which all the copper was dissolved; with *crocus martis* it gave a dark brown scoria; with calx of tin, a beautiful white mass; calx of antimony afforded a whitish scoria; calx of bismuth, a yellowish green mass; flowers of zinc afforded the whitest mass, it was semitransparent, resembling opal. All these, except the silver, formed mixtures, that did not deliquesce or melt. With chalk it formed a semitransparent body, like glass, and not deliquescent; with finely pulverized marble, it melted so thin, as to run out of the crucible, a small remnant only was left, vitrified; the same with respect to alabaster; with spanish chalk it gave



a somewhat porous mass, the fracture of which was shining and semitransparent; with a Saxon topaz, a beautiful opal coloured mass, and not deliquescent; with flint, the same, but deliquescent; with fine white clay, the same as Spanish chalk; with fluor spar a semitransparent mass. Distilled with oil of vitriol, the mixture on boiling became brownish, and then turbid and white; at a stronger heat the oil of vitriol came over, and the remainder was opaque, white and deliquescent; with strong spirit of nitre, the latter came over, and the remainder was transparent like borax-glass; with *spiritus salis*, the salt being fixed, nothing remarkable was observed; with pure salt of tartar, nothing arose, although exposed to a red heat; being dissolved in distilled water and crystallized, the crystals were long and had an excess of alkali, hence the necessity of repeated solution and crystallization. Exposed to the strongest degree of heat with pure vitriolated tartar, a heavy acid drops came over which effervesced with fixed alkalis, and when crystallized, resembled vitriolated tartar. The remainder was white and fused, difficultly crystallizable, and differed from vitriolated tartar, likewise, in being easily soluble in a little water. Pure nitre being exposed with it to a strong heat, red vapours arose, a proof that this salt expels the nitrous acid from its alkaline bases; the remainder was of the colour of peach flowers, but had not so perfectly become fused, as that with vitriolated tartar, and was more difficultly soluble in water. On evaporation the crystals were longish, resembling those obtained from salt of tartar. They did not detonate on hot coals, but by the blow-pipe became a round mass, like that from salt of tartar which became opaque on cooling. With common salt, the same as last, the spirit of salt came over, and the remainder was milk-white, easily soluble in water, and afforded cubic crystals, which decrepitated on red hot coals; there was, however, some difference; with sal ammonia, no change



took place; with finely powdered borax, the fusion was so subtle as to pierce the sides of the crucible; the little remaining had glazed the bottom of the crucible, but did not attract moisture. This salt dissolved in two parts of water and mixed with lime water was left to evaporate on a moderately warm furnace, and during the evaporation (from 1 quart to 10 ounces) a great quantity of fine white porous earth had been deposited at the bottom; this filtered and dried was not fusible, but effervesced with aqua fortis; the filtered liquor afforded a yellowish radiated salt, that did not deliquesce; this salt dissolved in two or three parts of water, when it was perfectly clear, and precipitated the following earths from their solutions: flint dissolved by fixed alkalis; calcareous earth from acid of salt of a white colour, which was remarkable for being for the most part as birdlime after edulcoration; and the earth of alum. It did not precipitate gold from aqua regia, but silver fell down of a white colour from the nitrous acid. It precipitated copper from nitrous acid, in the form of a white powder, often likewise in the form of a green oil, and oftentimes had no effect, which arose from the proportions of the water. Iron fell from the nitrous acid likewise; and as a white powder from spirits of salt; the precipitate was tough in the heat, but boiling water entirely dissolved it. Lead fell down from nitrous acid of a white colour, as well as tin dissolved in aqua regia, but this last metal was not precipitated from the vitriolic acid. Quicksilver from the nitrous acid and bismuth equally produced a white powder; after some time it precipitated zinc from the nitrous acid. Such are the experiments which Margraaf made upon the phosphoric acid, and later observations have confirmed some and added to others.

With respect to it's taste, Leonhardi thinks it resembles that of vitriolic acid, and shows no particular sharp-

Taste of  
phosphoric  
acid.

nefs, although de Laffone and Cornette have described it as caustic.

Specific gravity.

It's specific gravity according to Morveau cannot be determined in a state of fluidity, as it may be dephlegmated to dryness; in a vitreous state Crell found it to water as 3 to 1, but as his acid had not been in a state of phosphorus, it was not perfectly pure. It's concentration even varies in a liquid state, from it's spontaneous deliquescence; the strongest which Morveau saw, was 1,417, another time only 1,306." According to Brisson, the specific gravity of a phosphoric acid, a cubic foot of which weighed 109 lb. 3 drachms  $11 \frac{2}{3}$  grains, was to distilled water as 15575 to 10000. But de Laffone and Cornette mention some of this acid that was to water as 19 to 8.

With water.

These two last chemists have also observed the heat produced on mixing this acid with distilled water. With an acid of the consistence of oil of vitriol they raised the therm. (Reaum.)  $45^{\circ}$ ; with another acid of a specific gravity to water as 19 to 8, they raised it from  $13^{\circ}$  to  $34^{\circ}$ , and another time, when two parts of this acid were added to one of water,  $4^{\circ}$  more.

Nitrous gas.

Priestley observed, that this acid was soon saturated with red nitrous vapours, or nitrous gas, and then became of a deep indigo colour.

Potash.

The salt it forms with potash has been called tartarus phosphoratus, alkali vegetabile phosphoratum. It crystallizes without difficulty; when exposed to heat in close vessels it is not decomposed, but becomes an opaque vitreous mass, soluble in water. It is decomposed by lime water, and by selenite solutions, the phosphoric acid uniting and precipitating with the earth, forming a phosphoric salt of lime. Although it decrepitates on the coals like common salt, yet it did not with the blowpipe according to Margraaf, but was converted with borax into a

transparent vitreous body. It does not communicate, as well as other phosphoric salts, any colour to the flame of alcohol, although it contained a few reddish parts. It is decomposed by fluoracid and a float of potash containing filix is precipitated. It is not decomposed by the acid of arsenic, but is in part by that of tartar. Silver precipitates it in the form of a fine white powder, by double affinity; quicksilver, of a yellowish colour, and lead, of a darkish white powder.

By a small superabundance of acid when united to soda <sup>Soda.</sup> this salt is said to possess the peculiar property of being fixed in the cold and fluid at an evaporating heat, without the aid of water. Limewater decomposes its aqueous solution; alcohol, acids and the above mentioned metals, act upon it as upon the phosphat of potash, but the acid of tartar does not decompose it. It has been called, *sal phosphoreum minerale*, *sel phosphorique à base de l'alcali minéral*; when properly saturated, it effervesces in the dry air like other salts with basis of soda, and being free from any unpleasant taste, has been of late years introduced into medicine as a purging salt.

Dr. Pearson gives the following process for preparing this phosphat of soda. Dissolve in a longnecked matrass 1400 grains of crystallized mineral alkali in 2100 grains of water, at the temperature of  $150^{\circ}$  of Fahrenheit's scale. Add gradually 500 grains of phosphoric acid, of a specific gravity to water as 1,85. Boil the liquor some minutes, and while it is boiling hot, filtrate it and pour it into a shallow vessel; let it remain in a cool place, and crystals will continue to form during some days. From the above quantities of the materials, he has obtained from 1450 to 1550 grains of crystallized salt. The crystals are solids contained within six rhomboidal faces, of which the acute angles are  $60^{\circ}$  and the obtuse  $120^{\circ}$ .

United with ammonia it forms the *sal ammoniacum* <sup>Ammonia.</sup>

phosphoreum, or sel phosphorique ammoniacal, the solution of which is likewise decomposed by lime water. According to Lavoisier, it's crystals resemble those of alum, and are easier soluble in warm than cold water; they require from five to six parts of cold water for their solution, and are not deliquescent. According to Wenzel the ammonia is to the phosphoric acid in them as 8 to 3. This salt swells when exposed to the fire, but although it is decomposed, the fixity of it's acid prevents it's sublimation. It is found ready formed in urine, and is the saline substance from which phosphorus is obtained in the process for preparing it from that animal liquor; for the volatile alkali escapes by heat, leaving the phosphoric acid at liberty to combine with the inflammable matter, and to form phosphorus; whereas the other phosphoric salt obtained in urine, which has just been mentioned under the name of phosphat of soda, is incapable of decomposition by charcoal.

#### Lime.

With lime, according to Wenzel, it forms a gummy mass, and a few crystals, but the greater part is in the form of a gritty powder which sinks to the bottom. In fact, says Ker, this compound is almost insoluble in water, and the part which remains suspended, or appears in crystals, as Wenzel describes, is merely dissolved by the superfluous acid. Lime has the greatest affinity to the phosphoric acid, which takes it from the nitrous, muriatic, fluor acid, arsenical and acid of ants, lactic and acids of lemons and vinegar; even in the dry way, from the fluor acid. This almost insoluble salt is called *sal calcareum phosphoreum*, *calx phosphorata*, *sel phosphorique calcaire*, and is prepared the best from strong lime-water or chalk and the phosphoric acid. From it's difficult solubility in water and consequent difficult crystallization, the real state of it's crystals cannot be determined, but from their changing the tincture of litmus to



a red, they appear to have a superabundance of acid (calcareous phosphit.) It is, however, soluble in the nitrous and vitriolic acids, and is acted upon, with respect to the separation of it's acid, in the same way as the earth of bones. Caustic alkalis have no effect upon it either in the moist or dry way; the precipitate of phosphat of lime, supersaturated with the acid, and made soluble by caustic alkali, is phosphat of lime; mild alkalis, according to Lavoisier and Morveau, decompose it, both ways, by means of double affinity, although in the dry way, from the surplus of alkali, very imperfectly. Mild volatile alkali likewise attacks the phosphat during the digestion, so as to produce a phosphat of ammonia; but it does not decompose it's solution so well by a quick precipitation, because the phosphat of lime becomes insoluble by depriving it of the superabundant acid, and falls down undissolved to the bottom. A solution of silver is precipitated by it, of a dirty gray, but by degrees becomes reddish, and a solution of quicksilver in the form of a white powder. It does not colour the flame of alcohol.

Morveau combined this acid with ponderous earth, by *Barytes*, adding it to a solution of this earth in marine acid, upon which the phosphoric acid separated the earth from it's solvent, and formed with it an insoluble precipitate. It has been called *terra ponderosa phosphorata*, *phosphoreum barytatum*, *phosphate de Baryte*. It is without taste, and in a state of powder. Made soluble in water by means of a surplus of phosphoric acid, it is more or less decomposed by the acids of vitriol, sugar, amber, and fluor, and perhaps, also, as Bergman says, by mild alkalis.

With magnesia, this acid forms, according to Wenzel, *Magnesia*, beside a very difficultly soluble powder, and a gummy mass, some small shining crystals, insoluble in nitrous acid, and which melt in the furnace to a porcelain-like substance.



According to Bergman, similar crystals arise when the acid is added to a solution of magnesia in vinegar. Lavoisier obtained by spontaneous evaporation, fine, flat, smooth needles, a few lines in length, cut obliquely at both ends, and which, when exposed to the air, fell in pieces; they resembled those that gypsum gives by a long and almost imperceptible evaporation. This salt is called *sal phosphoreum magnesiæ*, *magnesia phosphorata*, *sel phosphorique de magnésie*; or, according to Weigel, *bitterphosphorsalz*.

This salt is also obtained by the decomposition of all magnesian salts, except those of the acids of fluor and sugar. By alcohol, its solution is rendered turbid. All mild alkalis decompose it by digestion carried to a boiling heat, and the fixed on calcination. Limewater precipitates magnesia from its solution, and the precipitate falls with phosphat of lime. Gypsum the same by double affinity.

Argile.

The phosphoric acid (according to Wenzel) easily unites with pure clay when digested upon it, forming an insoluble saline powder, and a clear fluid solution, which, by evaporation, yields a gritty powder, and at last, a matter resembling gum arabic, which, by heat, becomes a transparent glass. This has been called *alumen phosphoreum*, *argilla phosphorata*, *phosphate d'alumine*, *alaunerdichtes phosphorsalz*. The acid of vitriol, caustic, and mild alkalis, limewater, and magnesia easily decompose it. Vinegar even takes the argile from the phosphoric acid, according to Bergman.

Silex.

This acid has not any sensible effect upon silicious earth, in the humid way, although it has been observed by Rouelle to attack glass.

In the dry way, Ker observes, that this acid acts upon all earths. Margraaf, as before observed, exposed to heat mixtures of three parts of acid with one part of Saxon topaz, flint, clay, and chalk, and obtained from

each of these earths, vitreous masses, more or less transparent: of all these glasses that made with flints was the only one which seemed to be deliquescent.

Lavoisier found, that leaf-gold, which he had changed Gold. into a very fine purple powder by trituration with sugar, and washing it with water, lost nothing of it's weight after being twelve hours boiled with dilute phosphoric acid, and that an alkali precipitated nothing from it. According to Margraaf, the addition of nitrous acid did not render it capable of dissolving this metal, which shows, that Stahl's idea of the identity of this acid with the marine is not well founded.

According to Wenzel's experiments, the phosphoric acid seized upon some silver that had been produced from Silver. luna cornea, and actually in part dissolved it. Some precipitated calx of silver, on digestion with this acid, was coloured black; and although there was no appearance of solution, yet after the evaporation of the clear liquor, a saline substance remained, which, by the blowpipe, was melted to a dark, dirty, opaque glass. The edulcorated black powder exposed to a red heat, became yellow, and by a stronger heat, part was reduced, and part vitrified, of a dark colour. Common salt precipitated the solution, bluish; likewise the alkalis and metals precipitate silver from this acid. As this acid does not precipitate this metal from it's solution, of itself, Leonhardi thinks, that in Margraaf's experiments, where the black flocculi of silver were deposited, it was owing to some phosphorus that was present, as that substance precipitates many metals in their metallic state.

The solution of the calx of copper, precipitated by an Copper. alkali, in this acid, affords, after evaporation, a green transparent mass, resembling gum arabic, which melts, by the blowpipe, to a perfectly dark opaque glass. By fixed alkalis, the solution, according to Wenzel, is pre-

precipitated green, but by zinc and iron, in it's metallic state. It does not precipitate the vitriolic, nitrous, or muriatic solution of copper, but precipitates that of verdigris. The phosphoric acid prepared from the ashes of bones containing a saline matter, on being fluxed with  $\frac{1}{36}$  of the calx of copper, and precipitated from it's muriatic solution by an alkali, the compound is a sea green glass; and it precipitates in the moist way, copper dissolved in muriatic acid, vinegar, or the acid of fat; from the two last acids, of a white colour. Lavoisier found metallic copper as soluble in the phosphoric acid as gold; that the union of the calx of copper was possible, but weak, and not fixed; and he employed this acid to separate copper from iron. Lavoisier attributes this inaction of the acid upon the metal, to it's great affinity to it's pure air, which prevents it's parting with it to the metal. Margraaf, it is evident, therefore, differs from the French chemist; and Ker observes, that probably this difference between the two illustrious chemists may be reconciled by supposing, that this acid is incapable of acting *directly* on copper, but that by *absorption of air* from the atmosphere, it becomes capable of dissolving it in the same manner as vegetable acids can.

The copper which this acid dissolves, is retained so weakly, that it may be separated by adding gold to the solution, which metal attracts the copper from the acid.

From what has been already said of this acid with  
 Iron, it appears that it is capable of uniting with it in two proportions. According to Margraaf, the compound is a crystallizable salt; but according to Morveau, only a white magma somewhat deliquescent. The difference of these results, Ker observes, depends on the different degrees of saturation of the acid; for Wenzel relates, that this acid makes a clear solution of iron, and by evaporation, crystals may be formed that do not de-

liquefies in the air, and which, by heat, are changed into a garnet coloured glass; but that, if the solution of the iron be continued till the acid is saturated, the whole compound of acid of iron will fall to the bottom, and become a dry adhesive mass, insoluble in water, and soluble in spirit of vitriol. From the solution of this precipitate in dilute vitriolic acid, the iron may be separated by lime, in its metallic state; by alkalis, in form of a gray powder, which is crystallizable on account of a portion of phosphoric acid it retains. Lavoisier received only a greenish, saline substance, soluble in water, and by further saturation, during the solution and evaporation, a grayish white precipitate.

Of all the compounds of this acid with metallic substances, that with iron is the most interesting, as it is said to be owing to a mixture of the phosphoric acid in certain ores of iron, that this metal acquires the quality called *cold-short*, which, by diminishing its strength, renders it less useful.

Some years ago, two excellent chemists, Meyer and Bergman, observed, about the same time, that when *cold-short iron* was dissolved to saturation in vitriolic acid, the solution, particularly after having been diluted with water, let fall a *white precipitate*, which beingedulcorated, and melted in a crucible with powdered charcoal, gave a white, brittle, and fusible regulus. A portion of this regulus being melted with a quantity of good iron, gave this iron a cold-short quality. Hence it was inferred that this metallic substance was the cause of this vicious quality to which the iron made from certain ores is subject; and Bergman, as Ker observes, classed it, rather too hastily, as a new semimetal, to which he gave the name of *siderum*, apparently from its relation to iron, being derived from the Greek word σιδερος, signifying that

metal; it has been called *fiderite* in English and French, and wassereisen by the Germans.

This substance, however, did not long enjoy it's new distinction as a semimetal; for it's discoverer, Meyer, and also Klaproth, perceived it's similarity to the compound made from iron and phosphoric acid. The latter chemist further discovered, that the substance called *native Prussian blue* was of the same composition. But although the resemblance between the fiderite and the artificial compound of iron and phosphoric acid, gave strong reason to believe in their identity; yet the proof by analysis was not obtained till Scheele added this to his former discoveries. Although other acids have a stronger affinity to the iron than the phosphoric, yet it was not possible to separate this acid, because these acids may actually decompose the fiderite; yet the phosphoric being the most fixed in the fire, the other acids will be expelled by heat, and leave the iron again with the phosphoric acid. Scheele, therefore, had recourse to the effect of a double affinity. He prepared a quantity of the white precipitate of the fiderite, by dissolving cold-short iron in dilute vitriolic acid, as Meyer and Bergman had done. He boiled this white matter in a fixed alkaline ley, by which he separated an ochre of iron. As the filtrated lixivium contained a superabundance of alkali, he saturated it with nitrous acid. He observed, that on dropping a little of this saturated liquor to lime water, an earthy powder, similar to the earth of bones, was precipitated, which indicated the presence of the phosphoric acid. He then poured into the saturated lixivium, by degrees, a solution of mercury in nitrous acid, till no more mercurial precipitate was thrown down. This precipitate, which was a compound of mercury and the phosphoric acid, he mixed with charcoal powder, and by



distillation, obtained, first, the revived quicksilver, and then a phosphorus. He thus ascertained the existence of the phosphoric acid in the white calx, which precipitates from solutions of cold-fusible iron, and he confirmed by this analysis the synthetic results of Meyer and Klaproth. He had previously ascertained the justice of this mode of analysis, by trying it on an artificial compound of iron and phosphoric acid. It is evident, as Ker observes, that in Scheele's experiment, the alkali decomposed the siderite, separated the iron, and remained united with the acid in the lixivium; that by adding the solution of mercury to this lixivium (previously saturated by nitrous acid, in order to engage the superfluous alkali) the phosphoric acid was combined with the mercury, and this compound being insoluble, was precipitated, while the alkali united with the nitrous acid. The volatility of mercury by heat gave an opportunity of disengaging it from the acid, while this acid, uniting with the charcoal, formed phosphorus. By the same process, Scheele ascertained the presence of the phosphoric acid in the *native Prussian blue*.

Delievre has discovered, near Limoges, a perfect native phosphat of iron, *i. e.* the iron is entirely saturated by the phosphoric acid; it is of a red brown colour, is semi-transparent, and has a foliated texture.

Even when concentrated, this acid only acts weakly upon tin; it corrodes it, and a very unpleasant smell is <sup>Tin.</sup> emitted, according to Margraaf; at the same time, the phosphoric acid, which has remained upon this metal, neither suffers any precipitation by alkalis, nor is there any perceptible loss of weight in the metal itself. There is no precipitation even by tin, in a solution of phosphat of copper. The calx of tin is in part dissolved in this acid, but in small quantity; but it is in part so changed as to be very vitrifiable in the fire, according to Wenzel.

**Quicksilver.** According to Margraaf, this acid has no action on the calx of mercury precipitated by an alkali. Morveau found, that when the phosphoric acid was digested upon quicksilver, almost to dryness, then dissolved again and filtered, on the addition of an alkali, a whitish appearance was produced, but by evaporation, a brownish magma was obtained; yet, neither could the vitriolic acid, nor ammonia, nor even lime water detect the presence of mercury in it. Lavoisier digested diluted phosphoric acid with pure quicksilver for some months, in the cold, without any effect.

**Arsenic.** According to Margraaf, this acid perfectly dissolves white arsenic; the evaporated solution affords a black mass, which is tenacious, and for the most part volatilises on exposure to heat. It has very little or no action on the regulus; according to Morveau, a drop of alkali precipitates from the acid digested upon it a white earthy precipitate, but the second drop redissolves it.

**Zinc.** According to Wenzel, the phosphoric solution of zinc is incapable by evaporation of being brought to crystallize, as it affords only a white transparent mass, similar to gum arabic, which before the blowpipe is converted into a transparent, easily fusible glass. This phosphoric solution is precipitated by alkalis to a white vitrifiable powder. The uncrySTALLIZED mass, according to Morveau, is easily dissolved by water, without decomposition.

Crell, reflecting on Scheele's method of separating the phosphoric acid from its union with fixed alkali, by means of the double affinity of the nitrous acid to the alkali, and of mercury to the phosphoric acid, contrived a new process for obtaining phosphorus from bones, viz. by melting burned bones with fixed alkali, lixiviating the melted mass, saturating the filtrated lixivium with nitrous acid, adding to the saturated liquor a solution of mercury in nitrous acid, till the precipitation

ceased; and lastly, by adding to the precipitate some powdered charcoal, and distilling the mixture till the mercury first came over, and then the phosphorus. He proposed afterward to substitute, for the sake of cheapness, *vitriol of zinc* to the solution of mercury. But Westrumb affirms, that this substitute did not succeed well, little or no phosphorus being thus produced. From the experiments he made on this subject, Westrumb concludes, that vitriol of zinc is not capable of decomposing completely the phosphoric salt with basis of fixed alkali: 2d. that the phosphoric acid united with zinc cannot be easily separated from this basis, but that they rise together in the form of flowers: 3d. that this acid having a stronger affinity to zinc than to any other metallic substance, is still less capable of being separated from this metal by addition of inflammable matter, than it is from iron, when united with this latter metal in the substance called *siderum*. Crell remarks, upon Westrumb's conclusions, that it has been affirmed by other authors, that phosphorus has been actually obtained by distilling compounds of phosphoric acid and zinc; and that even Morveau had obtained a *little* by trying the process which Crell had suggested, although not enough to induce him to think favourably of the process itself. According to Ker, in order to explain the difference of the results which occurred to different chemists, it is necessary to have recourse to one of the most general and useful maxims in chemistry, viz. that bodies combine with each other in certain different proportions, and that their affinity to each other varies in strength in the differently proportioned compounds. Thus when zinc and iron are directly combined with phosphoric acid, the compounds formed contain a much larger proportion of acid than the precipitates do, which are deposited spontaneously from the solutions of these metals in that acid, or from

the solutions of other phosphoric salts, by adding a solution of iron or zinc in vitriolic or nitrous acids.

If then the former compounds of phosphoric acid and iron, in which the acid abounds, be mixed with charcoal, and distilled, the superabundant acid will furnish phosphorus. But when the precipitates are treated in the same manner, the smaller proportion of acid adheres too strongly to these metals to yield to the action of the charcoal. Hence neither Crell's process with the zinc precipitate could succeed, nor can phosphorus be obtained from *siderite* and charcoal.

**Antimony.** In the moist way, according to Morveau, the phosphoric acid dissolves a little of the regulus of antimony, but more of the calx precipitated by an alkali. From this solution, alkalis and zinc precipitate an ash-gray powder, easily vitrified; and by evaporation, a dark green matter is obtained, very tenacious, which foams on exposure to heat, and is converted into a white transparent glass. What remains of the undissolved calx melts, according to Wenzel, before the blowpipe, into an opaque, white glass.

**Bismuth.** According to Morveau, this acid attacks bismuth, and it dissolves in part the calx precipitated by an alkali, in such a manner, that from the clear solution crystals arise, that are fixed in the air, and soluble again in water; they foam in the fire, become black, and at last are volatilized; it, however, in part changes it to a saline powder, which is not acted upon by nitrous acid, is not fusible at the heat in which copper melts, and after some smoke, is baked to a light gray porous scoria.

Alkalis and zinc precipitate, according to Wenzel, the crystals of the phosphat of bismuth, in a gray powder, easily vitrified.

**Cobalt.** According to Morveau's experiments, this acid had no action on the regulus of cobalt, even in the heat; but it

attacked the calx at the boiling point, and formed with it a deep wine-coloured solution. Crell observed, as he digested the saline substance (containing this acid) obtained from the earth of bones, at first, a yellow solution to arise, which changed to a white, then violet, and at last to a purple coloured hard mass. Precipitated cobalt with the above phosphoric acid from bones, afforded in the cold a colourless solution; but on boiling, it became as fixed as the regulus of cobalt. By solution with water a reddish fluid was produced.

Pulverized manganese, according to Scheele, although Manganese. it dissolved in small quantity in this acid, yet afforded at last a saturated solution. According to Morveau, the solution of the calx of this metal appeared red; but by standing in the air became as white as the reguline solution; again became red on being filtrated upon the calx, and again lost its colour on exposure to the air. Morveau accounts for this change of colour, from the affinity of the calx to the principle of inflammability.

We are informed by Cornette, that weak phosphoric Oils. acid has little or no action upon oils. That which was to water as 19 to 8 mixed with an equal quantity of æthereal distilled, or expressed oils, of a similar temperature with itself, at first fell down to the bottom, without effecting any change; but on being stirred they became thicker, darker, and more fixed; while it became somewhat resinous, and in boiling water, in which it was very soluble, appeared milk white. Mild drying oils produce less heat with it, become at first likewise thickened by it, but on standing, separate in a thinner state than before, and are made by it soluble in alcohol. It, however, retains something of the oils, which is evident from its milk-white solution in water. The colour, consistence, and heat of mild fat oils are less changed by this acid, and they do not become soluble in alcohol, in conse-



quence. No oil is distilled with this acid that is butyrous, and no soap is produced with it.

According to Morveau, this acid has an evident effect upon oils; mixed in equal parts with olive oil, it becomes, by agitation alone, of a fawn colour, which remains even after the separation; this shade still increases, if the mixture be digested, the acid occupying the bottom part is thickened, the layer of oil in contact with it becomes black and carbonated, the whole acquires a strong odour, resembling that from a mixture of ether and oil of turpentine; the acid preserves this odour, even after having been diluted with a large quantity of water, and filtrated; and the oil still retains it after distillation. Thus, these two substances are reciprocally changed, and the academicians of Dijon were right in observing, that this circumstance ought to be attended to, as being able to cast some light on Dippel's oil, which is, perhaps, only the product of the ethereal union of the phosphoric acid with the essential animal oil.

#### Alcohol.

Margraaf has observed, that the phosphoric acid is insoluble in spirit of wine; this has been confirmed by Wenzel; and Rouelle, as before observed, has attempted, from this property, the purification of this acid. Wenzel places the acid salt of urine in the class of substances insoluble in spirit of wine. De Lassone and Cornette, say, that it coagulates the phosphoric acid as well as the lymph of animals; and Scheele, in his Dissertation on Ether, indicates spirit of wine, as a very good vehicle to take away, by distillation, the phosphorus that may happen to remain in this acid; yet, a long time ago, the academicians of Dijon observed, that from the miscibility of these two fluids, there was always a loss on purifying the phosphoric acid according to the process of Rouelle. This observation has been confirmed by Lavoisier, who mixed in different proportions,

spirit of wine and *phosphoric acid*, sometimes concentrated, at other times *phlegmatic*; and who affirms, that the effects are much the same as those arising from the mixture of this acid with water; that *heat is equally produced*, and that the thermometer rises nearly to the same degree. Lastly, in a memoir published in 1783, the Duke de Chaulnes recommends the purification of the native phosphat of urine by spirit of wine; and asserts, that the acid, which remains in the retort after the distillation of the impure salt, is deliquescent; and that what is purified leaves an acid, which preserves it's transparency and solidity in the air. From the difference of these chemists, Morveau is of opinion, the question would be difficult to determine, if the greater or less state of purity of the acid they used was only considered, that which Lavoisier and the academicians used being prepared by the combustion of phosphorus. But he thinks it very probable, that it still contained some undecomposed phosphorus; and it is well known, that phosphorus is soluble in spirit of wine, although it may be said, that so small a quantity could not serve as an intermedium to so large a portion of acid. Morveau, therefore, concludes, that the phosphoric acid does not form an exception to the general law, which submits all acids to solution by spirit of wine, only in proportion as they lose their acid characters, whether by taking a basis, or by being deprived of a portion of their acidifying vital principle, which brings us back to the hypothesis of the reduction of this acid to it's radical vitriform principle.

We are informed by Lavoisier and Cornette, that the phosphoric acid with spirit of wine produces heat very evidently; but that this acid does not, when strong and distilled with spirit of wine, afford any ether, but a fluid which approached near it in it's inflammability, according to Morveau. It had an unpleasant smell, which, as well

as it's manner of burning, proceeded from a portion of phosphorus, to be found by means of adding water to the extracted alcohol. The obtaining however of a phosphoric ether is said not to be void of all hope; for not only Westrumb obtained with a phosphoric acid (extracted from bones, purified by Wiegleb's method from the calcareous earth by means of spirit of ammonia, and from volatile alkali by means of heat) and manganese, distilled with spirit of wine, a spirit that smelled very like quinces, and which on rectification left a white earthy mark in the retort; and by inflammation upon water, a residue resembling garlick in smell; but Cornette likewise found, that on distilling a mixture of phosphoric acid and tartarized alcohol, a fluid first came over that smelled strongly of garlick, then one that was still stronger having the smell of ether, which tasted very differently from spirit of wine; and as he extracted fresh alcohol repeatedly from the acid residue, that which came over smelled always more aromatic; even after he had mixed all the fluid that came over with fixed alkali, a red matter fell down during a lively effervescence, that was difficult of solubility in water, and not crystallizable, and which he calls (*schweflichtes*, or *olichtes phosphorsalz*) sulphurated or oily salt of phosphorus (which Leonhardi looks upon to be only impure phosphorus). This being separated, the aromatic smelling fluid on distillation gave at first a fluid that smelled very pleasant, but less cooling and more suffocating, and which tasted very differently from vitriolic ether; it mixed difficultly with water; and then appeared a fluid, less pleasant to the taste and smell, which united more easily with water, and seemed to approach to the first, as Hoffmann's anodyne spirit does to vitriolic ether.

Although Margraaf, Rouelle, the duke de Chaulnes, and other chemists have directed the purification of the phos-

phoric acid by spirit of wine, yet, according to Ker, there is reason to believe that a portion of it is soluble in this spirit ; for Lavoisier observed, that not only heat was excited on mixing these two fluids, but when they were distilled, the acid was volatilized, as the liquor which passed was strongly acid, of a pungent, unpleasant, arsenical smell, inflammable with smoke and miscible with water in all proportions ; it precipitated silver and mercury, but not gold from their solutions, and although not an ether, it appeared an approximation to it.

Priestley, who had observed, that this acid saturated with red nitrous vapours became of a deep indigo colour, has announced another property of it, still more curious. Having digested it upon some minium from which he had expelled all the air by heat, and which was consequently in the same state as when it affords vital air by the nitrous acid, he obtained by means of heat a great quantity of elastic fluid, that came over in a very turbid state ; scarcely precipitated any lime water, but was very inflammable, burning with a brilliant white flame, and had the odour of phosphorus ; the minium was changed from yellow to a deep gray, and almost black colour. Morveau, on adding this fact to those of the revivification of gold in aqua regia, and the slow decoloration of a phosphoric solution of manganese, is inclined to believe, that the phosphoric acid retains, even after having lost it's state of sulphur, a portion of phlogiston, which it is able to yield under certain circumstances, and which at least gives it the faculty of acting like the phlogificated acid ; but on considering all these phenomena, it is necessary to be guarded against the phosphorus which almost always remains undecomposed in the acid. If alcohol assists in volatilizing it, this chemist has proved, that it contributes at the same time to reproduce, even by the moist way, a new portion of phosphorus ; hence, in such

Opinion of  
Morveau,

delicate experiments, an acid ought only to be trusted that has been evaporated, pushed nearly to a vitreous state, and then abandoned to deliquescence. To diminish the loss of the acid taken away along with the water, a retort, or at least a matrafs with a long neck should be made use of.

It's affini-  
ties.

*Affinities of the phosphoric acid.* According to Bergman, the affinities of the phosphoric acid are in the following order :

Lime.	Zinc.	Bismuth.	Spirit of wine.
Barytes.	Iron.	Antimony.	Phlogiston.
Magnesia.	Manganese.	Arsenic.	He places in the
Potash.	Cobalt.	Mercury.	same order the
Soda.	Nickel.	Silver.	earths and alka-
Ammonia.	Lead.	Gold.	lis, respecting
Alumine.	Tin.	Platina.	their affinities in
	Copper.	Water.	the dry way.

Phlogiston,

Wenzel looks upon this acid to have a greater affinity to phlogiston than alkalis, because by the aid of heat it is separated from alkalis in the state of phosphorus, and because phosphorus is neither attacked nor decomposed by alkalis. But, according to Morveau, it is necessary to recollect, 1st. that it is only the ammoniacal phosphat that passes to the state of phosphorus, and that parts with it's volatile basis by the action of heat alone, without the intervention of a third substance producing this decomposition by it's affinity ; 2. that phosphorus is not the acid, and even does not contain it entire ; hence it's affinities are different. According to Bergman, this acid comes after the vitriolic and dephlogisticated muriatic acids in the order of affinities with respect to phlogiston ; it is however certain, according to Morveau, that phosphorus is not decomposed by either of these acids. With respect to the first, Morveau observes, that phosphorus melts in it by the assistance of heat, that it then rises to the sur-



face, and that the portion in contact with the air gives some tokens of combustion, but the rest undergoes no change, and Laffone and Cornette appear to have observed the same. With respect to the second, phosphorus was preserved without any change in dephlogisticated muriatic acid gas obtained in a concrete form according to Berthollet's method, *i. e.* in the highest degree of concentration and power. It is unnecessary to inform the reader, that with respect to the affinity of this acid with phlogiston, as the last principle is now looked upon as merely imaginary, the opinions are erroneous.

Bergman has very properly placed lime as superior Lime. in affinity to alkalis, although the authors of the Elements of Chemistry, published at Dijon, assert the contrary, viz. that alkalis have a stronger affinity to this acid than earths. According to Morveau, if a caustic alkaline solution be poured into a solution of calcareous earth by the phosphoric acid, an abundant precipitate is immediately formed; in consequence of which, it may be supposed, that the alkali has a greater affinity with this acid than the lime; and it was this appearance that deceived Lavoisier on the order of these affinities, and Wenzel, on the existence of a peculiar earth in ivory; but as Bergman observes, the calcareous earth can be only held in solution in this instance by the excess of acid, and on taking away this excess of acid by an alkali, the insoluble earthy salt is precipitated; hence it is not a simple earth, but real calcareous phosphat that forms the precipitate. Let some lime water be poured into a solution of phosphat of potash, and a precipitate is immediately formed, which is the phosphat of lime; and if the quantity of lime water be sufficient the whole acid will be thus precipitated, and the alkali alone will be left in the liquor; this leaves no doubt of the superior attraction of the earthy basis. The case is different if a mild alkali is used; the phosphat of

lime is then decomposed by double affinity, and it is the lime united to the fixed air that is precipitated. According to Morveau, it was by such means that the Academicians of Dijon decomposed the ossæous earth, on treating it in the dry way with an alkali that contained the mephite of potash.

This acid gives up it's earthy bases to the vitriolic, nitrous, and muriatic acids. According to Ker, the superiority of the affinities of ponderous earth and magnesia is, however, not well determined; neither has the affinity of these earths compared with that of alkalis in the dry way.

#### Quartz.

This acid, in the humid way, when pure, has no action upon quartz. The property it has of being reduced to a glass of itself would seem to announce, that by the dry way, it ought to be a very powerful solvent of all the earths; but experience does not coincide with this apparent analogy. Morveau in 1779 tried it's fusing nature in the public course of the Dijon Academy; the acid obtained from phosphorus by slow combustion, or as it is improperly called by deliquescence, was reduced by evaporation to a dry and almost solid consistence, it was mixed in this state with an equal weight of pure vitrifiable sand, exposed in a crucible for two hours to the most violent heat of Macquer's furnace, yet the mixture was not vitrified, only a white, porous epake mass was found, and so refractory, that part of the crucible, which had been melted upon it into a glass from the violent heat, was not able even by contact to determine it's fusion. This observation agrees with that of Bergman, on the little degree of action of the native phosphat of urine, employed as a flux for quartz exposed before the blowpipe.

Since phosphoric acid has so little affinity to quartz, it is, according to Morveau, perhaps only by it's action upon other earths or fusing saline bodies, that it attacks

glass. According to Ingenhoufsz, when it is hot it dissolves glass exactly like the fluor acid, but it is not certain whether his phosphoric acid was pure, and particularly, exempt from the mixture of undecomposed phosphorus. The experiments of Priestley are more detailed: this philosopher employed an acid obtained from phosphorus by deliquescence: he put some of this to the height of one inch, into a glass tube 30 inches long, and one third of an inch in diameter, hermetically sealed; in this he kept the acid boiling several hours, without any evident alteration; he only observed, during the ebullition, a white vapour, which arose from 15 to 18 inches above the surface of the acid. He had hitherto kept the tube in a vertical position, but wishing to turn it, to let the liquor pass to the other end, and having applied the flame of a candle to some part of the tube that had been moistened with the acid, the glass was instantly covered with a white incrustation; and having repeated this process at each extremity of the tube alternately, the whole soon became solid, and the only remaining humidity in the tube was that adhering to its sides, which it was impossible to make run. A curious circumstance in this experiment was, that when the tube was very hot, pencils of light were sometimes seen in the interior, extending the whole length of the tube; and then one part of the tube always acquired a slight stratum of orange coloured matter, equal to that which remains on the glass in which phosphorus has been burnt in the open air. These phenomena afford Morveau no doubt but that the acid employed partook of the properties of phlogisticated phosphoric acid, whether by containing some undecomposed phosphorus, or by reproducing it from the contact of some phlogistic substance being accidentally present in the tube, or on the surface of the glass. Hence this chemist observes, it is not extraordinary that the glass was in some measure

attacked and covered with incrustations; but it is difficult to explain what Priestley adds, viz. that the white matter found in the tubes after this operation did not attract humidity from the air, and that after being washed it did not preserve any sensible humidity; for it is well known, that salts formed of phlogisticated phosphoric acid are deliquescent, and it is difficult to conceive, how the water which renders the acid liquid, remains, as Priestley supposes, in the composition of the earthy salt formed at the expense of the vitreous matter, without rendering it more soluble. Morveau, not satisfied with the experiments of former chemists, wished to know from his own experience, to what degree the concrete phosphoric acid acted upon glass; for this purpose, he took a small but very thick phial of green glass (white glass, from the manganese it contains, was liable to error, and being charged with phlogiston, is colourless). This phial was filled with phosphoric acid extracted from bones, reduced to a state of transparent deliquescent glass, and afterward pulverized, *i. e.* the purest that can be obtained in that way, the orifice covered with a small piece of well baked pottery, and placed in a crucible filled with quartz sand. After being exposed to the fusing heat of a furnace for one hour, he found the phial depressed in two places, as to the rest, but little deformed; it was however nothing but a vitreous, solid, and homogeneous mass, of a very light green, inclining in the middle to an opal whiteness; it had no longer any flavour or solubility; thus the two glasses were perfectly mixed. At the beginning a few vapours had pierced through the sand, as was expected, and had slightly agglutinated it. This chemist, however, confesses, that this experiment cannot be looked upon as absolutely decisive with respect to the pure phosphoric glass; as it is certain, that it contained a

quantity of ouretic glafs, which might have an evident influence on the refult.

The confiderable ebullition of aluminous earth with Clay. native phofphat in the effays by the blowpipe announces, according to Morveau, a fufficiently marked affinity; hence, he has obferved, that Heflian crucibles, in which the pureft phofphoric acid was pushed to vitrification, were covered with a vitreous coat. He does not, however, think, that the infolubility of the mafs, which he looks upon as the phofphoric radical, can be attributed to the formation of an aluminous falt. If this was the cafe, the crucibles would be eafily perforated, and they would be at leaft evidently affected throughout: inftead of which, the vitreous coat is only fuperficial; and what is worthy of attention, it is of a beautiful transparency, whilft it is at the centre of the phofphoric glafs, and far from the fides of the crucibles; and fometimes a whiter and more opaque matter is perceived, which is of equal infolubility.

The phofphoric acid gives up alkalis to the vitriolic, Alkalis. nitrous, and muriatic acids, even to the acetous in the moift way, but in the dry, it decomposes vitriols, nitrats, and alkaline muriats. It has been thought to have a ftronger affinity to alkalis than thefe acids, becaufe when a mixture of phofphoric acid and nitre, marine falt, or vitriolated tartar is expofed to a ftrong heat, thefe falts are decomposed, and their bafes are found to have united with the phofphoric acid; but this effect does not happen in the *humid way*, and is merely the confequence of the greater *fixity* of the latter acid, by which means the other acids yield to the force of the fire and are evaporated:

It precipitates filver from it's nitrous folution, and Metals, mercury from it's nitrous and vitricic folutions.

2. *Phofphorous acid*. Some years ago this acid was Phofpho-  
confounded with the phofphoric; chemifts had no idea ous acid.



that combustible bodies might be united with different proportions of oxygen, and that phosphorus by burning slowly formed another acid from what it did when a rapid combustion took place with deflagration. It was Lavoisier who made it known in 1777, that the acid obtained by a complete combustion of phosphorus formed very different combinations from what it did when the combustion was slow. In 1786, when Morveau published the chemical part of the *Encyclop. Mèthod.* this acid is distinguished from the phosphoric by the name of *acide phosphorique phlogistique*; and he begins by observing, that as the nitrous acid, on loading itself with nitrous gas, becomes phlogisticated nitrous acid, so ought the phosphoric acid, that contains a certain quantity of undecomposed phosphorus, to be called phlogisticated phosphoric acid; the principles and properties of these, as well as of the phlogisticated vitriolic acid, being entirely analogous, and each the solution of a sulphur by it's own acid. Sage gives this acid the name of *volatile fuming phosphoric acid*; and Proust observes there is always a portion of this volatile phosphoric acid, in the distillation of phosphorus, which is to the phosphoric what the sulphureous acid is to the vitriolic. The best account of this acid is given by Fourcroy in his *Système des Connaissances chimiques*. It is weaker and not so powerful as the phosphoric acid; contains less oxygen; and is the product of a combustion, long and only luminous, by which the phosphorus absorbs a smaller quantity of the acidifying principle, than when the combustion is rapid and violent.

How produced.

As the phosphorous acid is never found in it's natural state, it is prepared artificially by collecting it in a proper apparatus from the slow and only luminous combustion of phosphorus exposed to the air of the atmosphere. If phosphorus be left exposed to the atmosphere, so that the air is continually renewed, it begins by it's solution in the

azot gas, it then combines by degrees with the oxygen, and it's acid is conveyed into the atmosphere in the state of gas, whilst it's successive formation is accompanied by flashes of light easily observable in the dark. If, however, this process be performed in a close apparatus, without the air being able to circulate around the phosphorus, and into which the atmospheric air is only permitted in a quantity sufficient to keep up the luminous combustion, the acid formed envelopes the phosphorus with a vapour, white during the day, but luminous at night: this condenses on the surface of the phosphorus, and attracting the humidity of the air, dissolves and falls in the form of drops. These drops are the phosphorous acid, but the proportion of the principles, phosphorus and oxygen, cannot be ascertained on account of the water, which combining with the acid, liquifies it.

The method of procuring it, therefore, is to have an apparatus that will admit the air by degrees, and receive the acid as it becomes liquid. For this purpose, rolls of phosphorus are put into glass tubes, open above, and drawn to a point below, where they are also open; these tubes are placed in a large funnel, so that their extreme points may be directed towards it's stem, which is received in a decanter. By such means, the pieces of phosphorus being isolated, are not heated by contact, and are not subject to be exposed to inflammation by a rapid combustion, which often happens when placed naked by each other in the funnel. The funnel and decanter, placed on a plate, is then covered by a glass bell, having two small lateral holes with stoppers, that are taken out or not, according as it is necessary to increase or diminish the combustion. The bottom of the bell reposes upon water, with which the plate is covered, and which, at the same time, affords the acid a proper menstruum. The liquid phosphorous acid runs by degrees into the decanter, and about

three times the quantity of the phosphorus is obtained of it, which, before it's difference from the phosphoric acid was known, went by the name of *phosphoric acid by deliquescence*. The phenomena accompanying the formation of this acid, the weak light, and insensible heat, so different from the burning ardour and lively flame observed during the preparation of the phosphoric acid, prove, according to Fourcroy, that this acid not only differs from this last, by a smaller proportion of oxygen, but also by the state of this acidifying principle, appearing to be much less solid, and retaining more heat than the phosphoric, and these two differences explain those of it's properties.

It's properties,

The phosphorous acid thus prepared, according to the process of Pelletier, is in the form of a white liquid, of the consistence of a sirup somewhat ropy, forming striæ on the glass like an oil; this consistence, however, varies according to the state of the air during it's formation. It is more liquid when the air is very humid; it's specific gravity appears to be somewhat less than that of the phosphoric; it's sour, sharp flavour, which sets the teeth on edge, is not very different from that of the phosphoric, and the taste is not able to distinguish them, the excess of the phosphorus in this not being evident. It also reddens the blues of vegetables in much the same manner. It is not changed by light, which it refracts more strongly than the phosphoric, from it's density. With heat it is very different, and, according to Fourcroy, it is by it's action it is to be particularly distinguished from the other. When the phosphorous acid is exposed in a glass retort, it first loses a part of it's water; when concentrated, blebs suddenly arise from the bottom of the vessel, and burst at the surface of the liquid, into a thick, white smoke, sometimes inflaming, when a sufficient quantity of air is in the apparatus. If this experiment be

Differs from the phosphoric.

made in an open vessel, each bleb exposes to the air a vivid deflagration, and expands an infectious odour, as if arising from phosphorated hydrogenous gas. These inflammable blebs continue a long time, and the phosphorous acid is not without great difficulty deprived of the matter, *i. e.* of the phosphorus that forms them by it's disengagement, and thus brought to the state of very pure phosphoric acid. This, however, after a long operation, is at last effected, and the remaining acid presents all the properties of the phosphoric already related. In making this experiment, it ought not to be forgotten, that the phosphorous gas only flies off when the phosphorous acid is very concentrated and hot, a proof, according to Fourcroy, that phosphorus not saturated with oxygen adheres to it very strongly.

There is very little affinity between oxygen and the phosphorous acid, although the last is not saturated with it, arising, as Fourcroy affirms, from the great adherence of phosphorus in phosphoric acid. To produce it, it is in vain to expose the phosphorous acid to oxygenous gas, it is only with extreme slowness it absorbs a small quantity. Indeed, it cannot be converted into the phosphoric acid by those means, and it succeeds only by a long ebullition; even the glass made of phosphorous acid appears still to retain a portion of phosphorus, as it differs from that made of phosphoric acid, by exhaling often a fetid garlic smell, and emitting sparks of light on being rubbed in the dark, which pure phosphoric glass will not. It is the same with the phosphorous acid exposed to the air; is very difficultly forms phosphoric acid, in spite of the tendency of the azot gas to dissolve the phosphorus by releasing it's bond with the phosphoric acid. It may be exposed many months to the air without being converted into phosphoric acid, but it is somewhat sooner if it be diluted with a quantity of water. This indisposition of the acid to

It's action  
upon differ-  
ent bodies.



change, makes it differ from several other acids that may be compared with it on account of their weak acidification, and the superabundance of their radical.

Hydrogen and hydrogen gas have no action upon the phosphorous acid. It is decomposed by carbon, red hot, which separates more phosphorus from it than from the phosphoric acid, because it contains more. In the cold there is no change; sulphur has no action upon it in the cold, nor in the heat; because the excess of phosphorus escapes before it can unite to the sulphur. It has no effect on the diamond. The action of this acid diluted with water, on those metals that decompose this last fluid more or less, differs from that of the phosphoric, by the hydrogen gas disengaged. This gas contains a small portion of phosphorus in solution, which renders it very fetid, without, however, it's being inflammable in the air, the quantity not being sufficiently great. This disengagement of phosphorus dissolved in hydrogen gas, according to Fourcroy, announces the combination that takes place to be only that of the phosphoric acid being deprived of the substance that constituted it phosphorous acid.

It is soluble in water in all proportions, but on disengaging this liquid in order to concentrate it, the phosphorus towards the end of the process leaves the acid, which becomes phosphoric acid. It cannot therefore be had solid, not because of it's adherence to the water, but because it loses at the same time by the heat, the excess of phosphorus from which it derived it's distinguishing character. This acid unites to most of the metallic oxyds with which it forms salts nearly insoluble. Some give up to it, even at a low temperature, a portion of their oxygen, so that by approaching to a metallic state, they convert it into phosphoric acid. This acid is stronger than the carbonic, and weaker than the phosphoric acid; it separates most bodies united to the first, even water, in the



form of gas, and it gives up to the second almost all it is united with.

The phosphorous acid, with alkalis and earths, forms *Phosphites*, salts that are called *phosphites*, of which the generic characters are, to emit a phosphorescent flame on being heated; to give a little phosphorus when exposed to a great heat, and thus repass to the state of phosphat, but in less quantity than before. The phosphite of potash has a saline acute flavour, very little luminous before the blowpipe, very little deliquescent, very soluble, and more so by heat, and is precipitated by the solutions of lime, barytes, and strontian; its form is a prism, with four sides terminated by a diedral summit. Phosphite of soda, is a four-sided prism, with a pyramid of four sides, it effloresces slightly, is somewhat more soluble by heat than in the cold. Phosphite of ammonia, affords before the blowpipe strong phosphoric sparks, and a flame with a white vapoury ring, and furnishes phosphorated hydrogenous gas by distillation. Phosphite ammoniaco-magnesian unites to the weak property of the preceding, that of affording sulphat of magnesia with sulphuric acid. Phosphite of alumin is styptic, of a gummy consistence, and swells in the heat. Phosphite of lime is in the form of powder, very neutral, pungent when acid, not to be decomposed by any basis. Phosphite of barytes is an insipid powder, very luminous before the blowpipe, the acidule is more soluble than that of lime; its solution is rendered turbid by lime water. Phosphite of magnesia is insipid, in flocks; or very small tetraedral crystals, it effloresces, and is very little soluble. With respect to the proportions of the component parts of the phosphites, they are as follows:

Phosphite of potash . . . .	Phosphorous acid . . . .	39.5.
	Potash . . . . .	49.5.
	Water . . . . .	11.

Phosphite of soda . . . . .	Phosphorous acid . . . . .	16.3.
	Soda . . . . .	23.7.
	Water . . . . .	60.
of ammonia . . . . .	Phosphorous acid . . . . .	26.
	Ammonia . . . . .	51.
	Water . . . . .	23.
of lime . . . . .	Phosphorous acid . . . . .	34.
	Lime . . . . .	51.
	Water . . . . .	15.
of barytes . . . . .	Phosphorous acid . . . . .	41.7.
	Barytes . . . . .	51.3.
	Water . . . . .	7.
of magnesia . . . . .	Phosphorous acid . . . . .	44.
	Magnesia . . . . .	20.
	Water . . . . .	36.

Phosphites  
mistaken for  
phosphates.

Chemists, without suspecting it, have been employed in the examination of alkaline and earthy phosphites. For using the acid prepared from the slow combustion of phosphorus, they imagined they were forming phosphates, instead of which the formation of phosphites was the effect. Hence Lavoisier observed on the combinations of the phosphoric acid, from a rapid combustion, that if the products of other chemists were different from his own, it arose from their employing another acid, *i. e.* the phosphorous. It is to Foureroy and Vauquelin that we are indebted for a systematic investigation of these salts, for before, these phosphites were little or not at all known.

Method of  
distinguish-  
ing them.

It is necessary to recollect, that the phosphorous acid differs from the phosphoric, by a less quantity of oxygen, or a greater proportion of phosphorus; that it is formed at a less temperature, and by slow combustion, that it may be looked upon as a solution of phosphorus in the phosphoric acid; although it cannot be thus prepared, because the heat necessary for this solution has more affinity to the phosphorus than this last to the phosphoric acid.

Hence, when liquid phosphorous acid is heated some time, a luminous thick white vapour arises in the dark, which is lighted at a certain degree of temperature, and is volatilized phosphorus, which being once separated from the phosphorous acid, leaves it in a state of pure phosphoric acid. These characteristic properties of phosphorous acid are the real causes of those that serve to distinguish the phosphites.

All phosphites are the production of art; by uniting their bases with the phosphorous acid, and evaporating and crystallizing the solutions when capable of it, and washing them well, when not. Some are formed by a double attraction, by mixing solutions of phosphites with those of nitric and muriatic salts. Although these phosphites agree in some respects with phosphates, they differ from them in others. Their form, when susceptible of a regular one, is always more or less different from that of phosphates with the same basis. Their flavour is not the same, that of phosphites having always something fetid, acid and of garlick, not perceptible in phosphates. Their properties.

All phosphites are fusible, afford, on being heated in close vessels, a little phosphorus, thus passing to the state of melted phosphates, and are then unchangeable. Before the blowpipe, all melt into a vitreous, transparent, or opaque globule, and all emit on fusion, a phosphoric light, often even sparks of flame, accompanied with a strong smell of garlick, and a white thick vapour, not observed in phosphates. After this vitrification, they are converted into phosphates, less in quantity than when phosphites. They undergo no change in the common air, and differ, as to the water they contain, according to the species. Combustible bodies have no more effect upon them than upon phosphates. Some are very soluble in water; others weakly; and others not at all. Several are more soluble in heat than cold, and crystallize on cooling. They often

reduce metallic oxyds by contact or by heat, and then become phosphats by taking oxygen from these oxyds. They are nearly all decomposed by acids, even by some that are weaker than the vegetable; which proves this acid to have less attraction for the bases than the phosphoric has. This last disengages the phosphorus from them. The phosphorous acid renders several phosphites more soluble, to which it adheres, and which it brings to a state of acidulous phosphites. The nitric and oxygenated muriatic acid immediately change phosphites into more abundant phosphats. The bases have a different attraction for the phosphorous than the phosphoric; hence phosphites follow different laws of composition from phosphats. Lime and magnesia are here superior to fixed alkalis in attraction, and barytes yield it to lime. They in general decompose other saline earths, except those with the same basis. Nitrats and suroxygenated muriats, with which they detonate by heat, change them into phosphats. Suroxygenated muriat of potash inflames and detonates with them by simple percussion, from the excess of phosphorus they contain. They often reduce to a metallic state, more or less so, oxyds dissolved in acids. Such are the general characters of phosphites as described by Fourcroy.

The phosphorous acid attacks glass in the humid way, but its action is slow and very weak, and by no means to be compared to the action of the fluoric; it however acts more powerfully than the phosphoric acid.

Encyclopéd. Méthod. art. Acide Phosphorique, tom. 1. part 1. p. 202. Chimie.—First part of a Dictionary of Chemistry by J. Ker, art. Phosphoric Acid.—Philosophie Chimique, p. 6, 63.—The most advantageous method of obtaining phosphoric acid, by Mr. Suëron, Apothecary of Kiel, in the Nordisch. Archives, No. 2.—Boyle's Philo-

ph. works, by P. Shaw, M. D. 3 vols. art. Artificial Phosphori, London, 1723.—Margraaf's *Chemisch. Schriften*, Berlin, 1768. p. 51, 84. 1 Keil.—Macquer's *Chem. Wœrterb.* 3 K. art. Phosphorsaure.—Account of a Memoir of Mr. Proust, on several interesting Points of Chemistry, *Nicholson's Journal*, No. 45, p. 355.—Crell's *Neuest. Entdec.* t. v. f. 135.—*Journal de Phys.* par Rosier. t. 26. p. 187, t. 28. p. 30—De Laffone and Corvette, and in Crell's *Chem. Annal.* 1786. 2. p. 463, Uebersetzt von Mém. de l'Acad. des Sciences à Paris, 1780 —Wenzel von der Verwandtschaft, f. 220.—Crell's *Chem. Journ.* t. 4. f. 93.—Sur le Carbone retiré du Phosphore, Extrait d'une Lettre de M. von Crell, au Citn. van Mons. an de ch. t. 23. p. 325. 1797.—Extrait par le Citn. van Mons. sur la Crystallization de l'Acide Phosphorique, *ibid.* p. 74.—Système des Connoissances Chimiques, &c. par A. F. Fourcroy. t. 2. p. 43. t. 3. p. 230.

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#### SEBACIC ACID.

It appeared on treating of fat, that by the dry distillation of this animal substance, besides an empyreumatic, partly fluid, partly coagulated oil, an inflammable acid liquor was obtained, from which, by repeated distillation, an acid may be procured, known by the name of the sebacic acid, or acid of fat.

According to Fourcroy's definition of it, it is an acid extracted from fat by the action of the fire, likewise separated from it by alkalis and lime, with the assistance of a strong heat; it is a white, fuming liquid, of a very acid taste and smell, forming crystallizable and fixed salts, with earth and alkalis, decomposing the muriat of mercury, and is decomposed by a strong heat.

It had long been suspected, from the sharp and sensible

Sebacic acid.

Fourcroy's definition of it.



impression which the smoke of the fat of animals made on the organs of smell, that it contained a concealed acid. We are informed by Morveau, that Olaus Borrichius, in the Transactions of Copenhagen (Collect. acad. part. estrang. tom. vii. p. 374) has given a striking observation of the danger of the exhalations which arise from melting fat, which penetrate the nostrils, the eyes, and even the lungs. The effects, however, of these exhalations, were nearly all the proofs of an acid existing in that substance. They were likewise produced from the distillation of vegetable oils, and some animal matters analogous to them, and by the action of acids in the coagulation of fluid oils. It was principally on this last phenomenon, that Cartheufar, in his Elements of the Materia Medica, printed at Frankfort, in 1740, founded his opinion of the existence of an acid in fats.

These opinions, however, were but little better than conjecture; and the first person who proved by experiments, that animal fats really gave out an acid, was, according to Leonhardi, Francis Gruetzmacher, who published a dissertation on this subject, at Leipzig, in 1748.

Gruetzmacher first proved the existence of an acid in fats.

In 1753, a more exact analysis of fat, and a more convincing proof of the existence of this acid in fat, was published by Rhadés, at Gottingen, in a little work entitled, *Dissert. de Ferro Sang. Hum. Aliisq. Liqu. Animal.*

Rhadés.

Segner and Knape.

In 1754, Segner and Knape published a dissertation on this acid, which contains some well-made and ingenious experiments on the subject.

It's existence opposed by d'Aumont.

The experiments, however, of these chemists did not prevent d'Aumont, when the first edition of the Encyclopædia came out, from maintaining against Cartheufar, that this acid had no existence, and that there was no such a fluid to be obtained in the analysis of fats. His article was afterwards corrected in the supplements of the

great Haller, who positively asserted, that the human fat and marrow afforded, by means of heat, a volatile empyreumatic and acid liquor, which effervesced with alkalis, reddened the sirup of violets, and produced crystals by it's union with volatile alkali. Haller asserts it's presence.

Macquer, in his chemical dictionary, had only just mentioned this acid; and it is to Leonhardi that chemists are indebted for the addition of the article Fett-saure in his German translation of that excellent work. Macquer.

For the most complete dissertation on this subject, we are obliged to Crell, who has endeavoured, by a number of well-directed experiments, to perfect the process for the separation and rectification of this acid, and to determine the properties of it's combinations with other substances. It is from the memoirs of this celebrated chemist, some experiments, repeated by Maret in the public lectures of the Academy of Dijon, and what the illustrious Bergman has said of it in his treatise on elective attractions, that Morveau has digested the article *sebacic acid*, in the Encyclopédie Méthodique. Crell.

#### OF THE PREPARATION AND RECTIFICATION OF THE SEBACIC ACID.

Crell, in order to separate this acid from it's oil as it is obtained by the distillation of fat, and at the same time to procure it in a state of concentration sufficient for the examination of it's properties, made a great variety of experiments, the greater part of which, it appears, only served to convince him of the difficulty of this operation. His method of obtaining the sebacic acid pure.

Having been persuaded, from his experiments on fat, that the sebacic acid was simply disengaged, and not produced during the distillation, he conceived the hopes of fixing and uniting it with an alkaline basis, which, at the same time, would convert the oily part into a state of

soap, so that nothing further would be necessary than to separate the neutral salt from the oily parts of the soap; and experience justified the theory of the process.

“ I covered”, says he, “ exactly 8 ounces of recent quicklime, before it’s extinction, with one pound of potash, and I left these two substances in a glazed earthen vessel until the lime began to be extinguished. I then poured three pints of water upon them, and reduced it, by means of ebullition, to one quarter, and filtered it. This ley was found to be as strong as that which goes by the name of soap-boilers’ ley, and supported a fresh egg in the same manner. I then took one quarter of this solution, added a little water to it, and boiled it with one pound of ox suct, until all the humidity was nearly evaporated, and the whole well combined together. I then added to it the remaining parts of the ley, and continued to boil the whole, stirring it from time to time, until the mixture became transparent, and, as it were, mucilaginous, and until it became, on cooling, of a gelatinous consistence; it had then all the appearance of common soap before common salt is added to it.”

The next circumstance, was to decompose this soap, and by such means to separate the oil from the neutral salt that would be formed. To do this, Crell preferred alum as the cheapest method; and because he had no fear of it’s decomposing the sesat of potash in the moist way.

He dissolved the soap prepared with the fat, in boiling water, and added to it a little alum, slightly broken. Scarcely was it in the water when the fixed oil arose to the surface; this he skimmed off, and repeated the process of adding alum, and skimming it, until nothing more arose to the surface. He then filtered the ley, which was of a yellow colour, and had a bitter taste, in order to separate entirely the precipitated alum, as well as

some parts of the fixed fat, which still floated on the top, and he evaporated it to dryness.

Having procured by these means, the sebat of potash, he endeavoured to disengage the acid from it by means of alum, in order to be certain of it's passing over without being mixed with the vitriolic acid; but he recollected, that the contact of the inflammable matter had favoured the decomposition of a part of the alum; and he was convinced, from an evident odour of phlogisticated vitriolic acid, perceptible at the mouth of the vessel, that the product would not be less changed with this foreign acid; he therefore returned to the use of the vitriolic acid, as the most simple method, and which did not require so much trouble, or so strong a fire.

He repeated these operations more at large, to determine exactly the proper quantities, and after many trials, he found, that to six pounds of the abovementioned prepared soap, of a gelatinous consistence, it was necessary to add nearly 22 ounces of alum previously dissolved in water; that after having filtered and evaporated the liquor, nearly 21 ounces of salt were obtained, part of which was vitriol of potash, part sebat of potash, and a little alum not decomposed.

To three parts of this saline residuum, four ounces and a half of common concentrated vitriolic acid are to be added, which give rise to heat and vapours; the whole is then to be distilled by increasing the fire by degrees, and the produce will be a little more than five ounces of a yellow, fuming liquor, which is the sebatic acid.

In general, this acid is sufficiently pure; it is, however, well to be certain of it's not containing any vitriolic acid. For this purpose, a little acetite of lead is to be poured on it, and if the precipitate be not perfectly soluble in vinegar, it is a proof of the formation of vitriol of lead, and that the sebatic acid contains a portion of the

vitriolic acid. But the most certain method is, to redistil the sebatic acid upon a portion of the same salt; and it is on this account that Crell recommends the reserve of one fourth part of it, because it not only leaves behind it all the foreign salts which may have come over with it, but also it's yellow colour.

The product of this rectification is a clear colourless acid, still, however, fuming, and of a very penetrating odour.

According to Morveau, this acid has been for several years demonstrated in the public lectures of the academy of Dijon, by Maret; and the processes indicated by Crell, have constantly succeeded, (vide *Nouvelles de la République des Lettres de M. de la Blancherie. Ann. 1782. No. 17.*)

Another  
method of  
procuring  
it.

Instead of reducing the fat to a state of soap by an alkali, it is generally decomposed by quicklime, in the following manner: The fat is previously melted in an iron pan, some pulverized quicklime is then added, and at the beginning it is constantly kept stirring; towards the end of the process a very strong heat is applied, taking care, by raising the vessel, not to be exposed to the vapours. When the whole is become cool, the fat is found to have undergone a loss of solidity; it is to be boiled in a large quantity of water, the ley filtered, evaporated, and a very acrid, brown salt is obtained, which is the *sebat of lime*. This salt is very soluble in water; but as it would be too tedious and even difficult to purify it completely by repeated crystallizations, it is easier effected by exposing it to a heat capable of roasting the oil that blackens it, after which it is sufficiently purified by one solution; it leaves it's oil on the filter in a state of coal, and nothing remains but to evaporate it.

As it is better to add more lime than is necessary for



saturation, in order to multiply the points of contact, and to render the decomposition of the fat complete, the solution generally contains a little quicklime, and this is easily taken away by the addition of some water impregnated with carbonic acid, which does not decompose the sebat of lime.

This salt, distilled in vitriolic acid, gives up it's sebatic acid in the same manner as the sebat of potash.

*Nature and properties of the sebatic acid.* This acid, Pure sebatic acid. when pure, is a pellucid, colourless fluid; but deprived of it's water, it is in a gaseous form. When, however, it is just extricated from fat, it is united with part of the It's properties. oil, which gives it a gold yellow, or reddish colour. The action of the fire likewise gives it a yellow colour.

It's aroma is insupportably strong, penetrating and suffocating.

It's flavour moderately acid, sharp, and burning.

It reddens the tincture of litmus, but scarcely the sirup of violets, and it effervesces with alkalis and earths in their mild state. United with potash to the point of saturation, it forms quadrilateral daggershaped crystals, fixed in the air. To the taste, they are sharp, saline, nearly ammoniacal, but milder. This salt does not inflame in the fire, or decrepitate when cast on red hot coals. On distillation, gray vapours arise, which form a gold yellow, but very weak acid, of the smell of spirit of tartar: the residuum is alkaline and mixed with coal. It is decomposed by the vitriolic, nitrous, and muriatic acids; and on distillation with these, it's acid part is forced over. Alum has the same effect. On the contrary, vinegar, fluor and phosphoric acids, and white arsenic, are incapable of decomposing this salt in the dry way, and consequently of liberating it's acid. This salt is the *sebaceum potassinum* of Bergman, or the sebat of potash.

With soda, it forms brownish crystals, which by mo-

derate fusion, solution, and evaporation, although somewhat difficult, yet at last form white spear-shaped crystals. This salt deliquesces by a gentle heat, but becomes solid again on cooling; from which, as a middle point, four-cornered crystals arise, ending for the most part in three-cornered, pointed pyramids. In the air, they effloresce and become white. They resemble in taste, *terra foliata tartari*.

The sebacic acid, saturated with volatile alkali, affords a white ammoniacal salt, capable of sublimation, and resembling common ammoniac in taste; and it's cooling property, but which cannot volatilize iron and bloodstone in the same manner as common ammoniac.

With lime, this acid forms an earthy salt, producing hexangular crystals terminating in a flat surface. The taste is sharp and saline, but not so burning as the muriat of lime. It is easily soluble in water; but insoluble in alcohol; nor does it deliquesce in the air. It is not decomposed by alum.

It does not form a crystallizable salt with magnesia, but unites with it into a gummy bitterish mass, which is very deliquescent in the air, called by Crell, *sal amarum animale*.

This acid unites to the earth of alum with the greatest difficulty. This earth, precipitated by fixed alkali, and still moist, on being dissolved and exposed to evaporation, formed with it a shapeless salt, that was harsh, and contracted the organs of taste.

This acid, according to Crell, has no action on flint; but Morveau is disposed to believe, that it acts, if not upon pure quartz, at least upon glass. Crell having digested it several times upon gold, always obtained a white, earthy precipitate, which was not calcareous earth; and Morveau thinks, that the acid acts upon glass in a similar way to the fluor acid. This conjecture appears to him

probable, from observing since, that the empyreumatic sirupy acid attacked and very sensibly wasted the glafs.

The sebacic acid, boiled upon gold leaf, and upon platina, appears to commence a solution, but so weak that Crell, after many experiments, desires a further examination. When mixed with the nitrous acid, it dissolves gold, even in the cold; it unites, although difficultly, with the calx of gold, and forms a crystallizable salt; it does the same with the precipitates of platina. The one affords yellow, the other yellowish brown crystals. It precipitates gold from it's solution in aqua regia of a yellow colour, and platina of a yellowish red. These precipitates, whenedulcorated, attract moisture from the air; but that of the platina, which is become grayish yellow, the least.

It dissolves metallic silver in small quantity, which is precipitated by muriatic acid, of a white colour, and by copper, in the form of metal. By means of long digestion, this acid dissolves the calx of silver, and affords small, dark coloured crystals. It precipitates this metal from it's solution in the nitrous acid, of a white colour; it deprives the vitriolic acid of it's silver, but yields it to the muriatic.

By repeated extraction from living mercury, it changes it into a silver coloured mass, which is not decomposed by common salt, but resigns it to copper in a metallic state. It deprives the nitrous solution of mercury of it's metal. The precipitate obtained from corrosive sublimate is in great part dissolved by it in the cold, and the extracted solution, by a moderate heat, affords a real white sublimate, which is extremely difficult to be dissolved in water, even by a digesting heat, and affords a white precipitate with potash, which is therefore very different from the common corrosive sublimate. With volatile liver of sulphur, this solution affords a black pre-

precipitate, which, in a short time, leaves a cinnabar; it colours copper white, even when rubbed upon it in a dry state. The solution of common corrosive sublimate precipitates the sebatic acid white, which is a peculiar character of it, and shows that this acid prefers mercury before any other. This acid changes the surface of copper, even in the cold, to a green colour; but by the assistance of heat, a solution is obtained, which, on evaporation, is inclined to crystallize, but deliquesces again in the air. It neither takes this metal from the vitriolic nor nitrous acid.

With iron, it affords a solution of an astringent taste, and needle-shaped crystals, which deliquesce in the air. It neither precipitates iron from its vitriolic nor nitrous solution.

It only corrodes lead in its metallic state, and causes a turbidness. It dissolves minium in larger quantity, and changes the insoluble remainder to a white powder. This sebatic solution of lead has a sweetish taste, and is not decomposed by common salt. It precipitates lead from its nitrous solution, and forms with it white, needle-shaped crystals, easily soluble in water, which being evaporated a pulverized mass is produced, not very capable of imbibing moisture, but decomposable by the vitriolic acid. According to Bergman, it decomposes the muriatic of lead. It precipitates the solution of the sugar of lead, of a white colour, yet this precipitate is again dissolved by strong vinegar, when it is perfectly free of vitriolic acid.

It corrodes pure tin filings in the cold, but more so by heat, to a yellow powder, from which an extremely disagreeable smell arises; by repeated filtration, this still remains turbid; but after reposing some time, it deposits a yellow powder, and receives a beautiful rose colour. This yellow corroded powder affords, with water, a white

salt, which readily deliquesces in the air. It deprives the reguline acid of it's tin. According to Bergman, this acid likewise decomposes the muriat of tin.

The sebacic acid has no effect on the regulus of antimony in the cold; but it readily dissolves it by means of heat, and produces, on evaporation, crystals, which are fixed in the air. If this acid be added to a diluted, saturated, reguline solution of antimony which has been filtered, and becomes no longer turbid by the addition of water, a white precipitate takes place, which, after edulcoration, digestion with water, and evaporation of the filtered fluid, affords a whitish yellow powder, that becomes moist in the air, and produces small crystals. According to Bergman, of all the acids, the sebacic most readily unites with the regulus of this metal.

It readily dissolves zinc, and in great quantity; but does not decompose the vitriolic and nitrous solutions of this metal.

This acid has no effect on bismuth in it's metallic state, even by a digesting heat. It dissolves, however, it's calx precipitated from nitrous acid, in the cold. This is precipitated by water, in the form of a white powder, although neither the vitriolic nor muriatic acid has any effect. This acid also produces from the common solution of bismuth, a white powder, although the solution has been made by so diluted a nitrous acid as not to be changed by the addition of water. The edulcorated precipitate, digested with water, filtered and evaporated, affords a white deliquescent residuum.

It has no effect on the regulus of cobalt, but readily dissolves it's calx. This solution mixed with saltpetre, and evaporated, affords a salt, which dissolved and exsiccated, forms a sympathetic ink. It does not precipitate cobalt from it's nitrous solution.



It does not dissolve nickel in it's metallic state, but forms with it's calx a green solution. This is not decomposed by the muriatic and nitrous acids.

It sparingly dissolves white arsenic in the cold, by the means of heat, more abundantly; on becoming cool, small crystals are deposited.

It has no effect on the nitrat of arsenic. It reduces white arsenic by distillation. It dissolves manganese in quantity, forming a clear solution, but does not decompose the nitrous solution of this semimetal.

Mixed with an equal quantity of highly rectified spirit of wine, it smokes without becoming very warm. If this mixture be extracted by a gentle heat after a previous digestion for six hours, it gives a liquid, which when added to water produces a milky appearance, and by degrees deposits an oily fluid, and is a kind of sebatic æther or naphtha.

The action of the sebatic acid on oils has not been examined.

The affinities according to Bergman.

With respect to the affinities which the sebatic acid has to other substances, they are given by Bergman in the following order:

*Moist way.*

Lime.	Lead.
Barytes.	Tin.
Magnesia.	Copper.
Potash.	Bismuth.
Soda.	Antimony.
Ammonia.	Arsenic.
Argile.	Mercury.
Calx of Zinc.	Silver.
Iron.	Gold and Platina.
Manganese.	Water.
Cobalt.	Alcohol.
Nickel.	Phlogiston.

*Dry way.*

Lime.
Barytes.
Magnesia.
Potash.
Soda.
Calces of Metals.
Ammonia.
Argile.

From this state of affinities it seems, Bergman has placed the earths before the alkalis; yet he appears to be doubtful of the alkalis yielding this acid to the earths, and on perusing his dissertation, he seems more willing to believe that the contrary ought to take place. This celebrated chemist, however, has not said upon what ground he formed this conjecture; but Morveau has seen it confirmed with respect to the caustic potash, which very certainly decomposes the sebat of lime. Morveau, therefore, has presented a table of affinities of this acid, in the *Encyclop. Méthod.* for the *moist way*, in the following order, acquainting his reader that the place of the barytes is not yet well determined.

According  
to Morveau.

Barytes.	Alum.
Potash.	Metallic calces.
Soda.	Water.
Lime.	Alcohol.
Magnesia.	Phlogiston.
Ammonia.	

In the *dry way*, the metallic substances go before ammonia and alum. It attracts alum so weakly, that if a solution of alum be poured into a solution of sebat of lime, no precipitation takes place.

Distilled upon alkaline vitriols, it disengages a little sulphureous vitriolic acid; this decomposition takes place, according to Morveau, by means of the phlogiston, which the most pure sebacic acid always contains.

It is not astonishing that it precipitates the acidulous tartrate of potash, when poured into a solution of tartar of potash, and also the nitrat of potash, although the nitrous acid deprives it of the alkali, in the moist way, because, according to Morveau, in the dry way, the nitrous acid becomes weak by phlogiston. With respect to the muriatic acid, when distilled with the sebat of potash, the acid which comes over, Crell says, precipitates the car-

rosive muriatic acid of mercury, of a white colour, which is the characteristic of the sebatic acid; hence Bergman, who had under his eyes the work of Crell, has put the muriatic acid before the sebatic, in the order of the affinities of alkalis, whether in the moist or dry way.

#### THE SEBATIC COMPARED WITH OTHER ACIDS.

Sebatic  
acid com-  
pared with  
other acids.

It is now pretty well ascertained, that this acid exists ready formed in fat, and in considerable quantity, since, according to Crell, two pounds of suet afforded him seven ounces two scruples of this acid. It likewise appears from the before-mentioned experiments, that this acid was directly separated from fat by means of alkalis and earths, even in the humid way, at least by a heat too weak to be regarded as the product of the fire; which facts are so very conclusive, as to appear to Morveau to need no other proof.

It attracts these substances, and forms new salts with their bases, which Morveau calls *sebats*, according to the principles of the new French Chemical Nomenclature. By means of heat, it is resolved into a gas; it is therefore, according to the last mentioned chemist, composed of vital air, the acidifying principle, and an acidifiable basis, like all other acids.

The action of the fire likewise gives it a yellow colour, and it leaves a residuum that announces a partial decomposition, on which account, Crell regards it as holding the medium between the mineral acids that resist a distilling heat, and the vegetable acids that are decomposed by it.

With the  
muriatic  
acid.

According to this chemist, it has some of the properties of the *muriatic acid*; thus it forms, with potash, a salt capable of melting in the fire without being decom-

posed; it acts powerfully upon gold when mixed with the nitrous acid; it precipitates the nitrous solution of silver; it forms a sublimate with mercury, which solution is not rendered turbid by common salt; and pure water separates antimony from it. It, however, differs from it in the most clear and evident manner by precipitating a solution of corrosive sublimate, which no other acid is capable of performing; and by its ammoniacal salt, when mixed and sublimed with salt of iron, not forming flowers containing this metal.

This acid has likewise been compared to *vinegar*, for, <sup>Vinegar.</sup> according to Bergman, earthy and alkaline salts have a very great analogy with those salts that are formed by the union of the acetic acid with the same bases; but it is very certain, that the salts of potash and of soda crystallize in prisms or in needles, and are much more fixed in the fire and air.

Gren formed a conjecture, that it was the acid of sugar, which he looked upon as confirmed by an experiment of Riecken, who, by extracting moderately strong nitrous acid from ox suet, obtained a very pure acid of sugar. Previous to this experiment, Scheele, having boiled some animal fat with about half its quantity of litharge, and a sufficient quantity of water, procured a sweet substance from the decanted liquor, which evaporated to the consistence of a sirup; and having repeatedly extracted nitrous acid from it, afforded him the acid of sugar. The difference, however, between the saccharine and sebatic acids, is now very well ascertained. <sup>Oxalic acid.</sup>

Metherie looks upon it as a peculiar acid existing in fat along with the saccharine matter, whilst it appears <sup>Other opinions.</sup> very probable to Leonhardi, that it is a peculiar modification of the common vegetable acid, differing in its

quantity of phlogiston, and holding the middle place between the saccharine acid and vinegar.

The analogy of this acid with the empyreumatic *oily acids* of some vegetables is according to the opinion of Morveau much better established, than with those already mentioned. Crell has extracted one by distillation of the butter of the cocoa, and having rectified and tried it's combinations, he found it precipitated the solution of silver; formed a crystallizable salt with lime, which did not deliquesce; and with the volatile alkali produced a real concrete ammoniacal sebat, very different from that which vinegar affords, &c.; from which he thinks that it was the sebatic acid. Having likewise found it in spermaceti and in human fat, and that of fish, and quadrupeds, he concludes, that this acid originates from the organized bodies of both the animal and vegetable world, and is an acid *sui generis*.

Experiments of  
Thenard.

The last chemist who has extended our knowledge on the sebatic acid is Thenard. The principal object of the experiments of former chemists was to prove that the product of the distillation of fat contains a peculiar acid of extreme volatility, and of such a poignant and suffocating nature, that it cannot be respired without some degree of danger. Those which Thenard gives an account of prove, 1st. That this product actually contains a peculiar acid, which however so far from being volatile, odorous and suffocating, is, on the contrary, solid and inodorous. 2d. That it contains acetous acid. 3d. That this new acid has no part in the smell of distilled fat. 4th. That by all the processes hitherto employed to extract the sebatic acid, nothing is obtained but a foreign acid, and that consequently the sebatic acid has not yet been known.

Methods of  
obtaining  
the sebatic  
acid.

Having distilled a considerable quantity of the fat of pork, Thenard, in order to obtain the sebatic acid, treated



the product at several times with hot water, and poured acetite of lead into the liquor; a flaky precipitate was formed, which being collected and dried, was put with sulphuric acid into a retort and heated. The liquid of the receiver had no character of acidity, but in the retort a melted substance floated at the top, analogous to fat, which being carefully separated and washed well, was boiled with water. By heat the water totally dissolved it, and by refrigeration crystalline needles were deposited, of little consistence; these needles were acid and had peculiar properties. To be certain they were not the product of the sulphuric acid, distilled fat was treated with water, and the liquor being filtrated and evaporated, needles were obtained having precisely the same properties. To procure this acid, likewise, the distilled fat being treated with water, the filtrated liquor may be saturated with potash, evaporated, and poured into a solution of lead. A precipitate is here formed which is a sebat of lead, that is to be treated as above with sulphuric acid. Such are the three methods Thenard employed to obtain the sebatic acid: according to this chemist it's properties are as follow;

It is without smell, it's taste slightly acid, it melts like a kind of fat, considerably reddens tincture of turnsol, and is more soluble in a hot than cold temperature. Boiling water, saturated with the sebatic acid, becomes solid by refrigeration; alcohol dissolves a large quantity of it; it crystallizes in small needles; with care it may be obtained in the form of long, large and beautiful brilliant lamellæ; it precipitates the acetite and the nitrat of lead, the nitrat of silver, the acetite and nitrat of mercury; it saturates the causticity of the alkalis, forming with them soluble salts; with potash it forms a salt that does not deliquesce, which has but little taste, and which, if sulphuric, nitric or muriatic acid be poured upon it, becomes

It's properties.

turbid and deposits sebacic acid; when it's solution is concentrated and mixed with one of these acids it becomes solid; finally, it does not render turbid the water of lime, barytes and strontites. These properties distinguish it from all the other acids, and prove it to be an acid *sui generis*.

To separate  
the acetous  
acid from  
the product  
after distil-  
lation of fat.

To separate the acetous acid from the product after distillation of fat, this product of the distilled fat is treated with water, the liquor saturated with potash and evaporated. When the substance is dry, Thenard introduced it into a retort with dilute sulphuric acid, or phosphoric acid, and distilled it, and an acid was obtained having all the characters of acetous acid; with potash it forms a foliated salt. This salt melts in the heat, and when exposed to the air, deliquesces speedily and completely, it's taste is extremely pungent; with a solution of nitrat of mercury, it forms a precipitate crystallized in the form of spangles. When sulphuric acid is poured upon it, acetous acid is disengaged in abundance. Sometimes the water with which the product of the distilled fat has been treated, contains scarcely any thing except acetous acid, so that to obtain acetite of potash, nothing more is necessary than to evaporate the liquid. The quantity of sebacic and of acetous acid formed in the distillation of fat, varies in proportion to the greater or less degree of heat.

The odorous  
matter of  
distilled fat  
examined.

In order to examine the odorous matter arising from the distillation of fat, Thenard introduced some fat, which had just been distilled, and the smell of which was extremely pungent, into a tubulated retort. He adapted to the neck of the retort a receiver which contained tincture of turnsol. Having distilled it with a gentle heat, the receiver became thereby filled with a strong odour, and yet the colour of the tincture was not changed, a convincing proof, he thinks, that the smell of distilled fat

is not owing to an acid; besides, if this smell depended upon an acid, he thinks, it would probably disappear upon placing it in contact with the alkalis, as the acid would then be absorbed, which is not the case. He therefore concludes, that it depends upon a portion of the fat, converted into gas, and undoubtedly changed in its nature.

In examining the different processes which former chemists employed to obtain the sebatic acid, Thenard begins with Crell, who in order to separate the sebatic acid from the product of distilled fat, first added to it a certain quantity of potash, after which he filtrated and evaporated it. As the salt he got was mixed with oil, he calcined it, redissolved it in water and evaporated the solution. By this means he obtained a salt of considerable whiteness and of a foliated texture, which being put into a retort with sulphuric acid and distilled, afforded a pungent and fuming acid. This process however appearing inconvenient, he employed another; for being persuaded the acid of fat existed ready formed in fat, and was not the product of distillation, he formed a soap with fat and potash, and treated this soap with water, in order to dissolve the sebat of potash formed in it. But as the water, besides the sebat, dissolved also some of the fat combined with potash, he added to the solution of this sebat of potash and of this soap a sufficient quantity of alum, by which he got sebat of potash with only an admixture of sulphat of potash; this he evaporated, poured sulphuric acid upon the dry substance, applied heat, and sebatic acid passed over into the receiver. In the chemistry of Dijon is a different process; the fat is there calcined with lime in a crucible; the substance lixiviated with a large quantity of water; the water holding the calcareous sebat in solution, evaporated; and this calcareous sebat is introduced into a retort with sulphuric acid, and the sebatic acid passes over into the receiver.

Processes  
hitherto em-  
ployed for  
obtaining  
the sebatic  
acid exam-  
ined.

These three processes Thenard repeated with great care, and obtained the following results. The first of Crell's processes, and that of the chemistry of Dijon, afforded him an acid that had all the characteristics of the acetous acid; with potash it formed a foliated deliquescent salt, of an extremely pungent flavour, and which treated with sulphuric acid gave a large quantity of vinegar. He thinks that if Crell, as he asserts, did obtain a fuming and pungent acid, it was a small quantity of sulphureous acid, proceeding from the decomposition of a certain portion of sulphuric acid, by the fat, or of the carbon of the acetous acid disengaged from its combination. In making the second process of Crell, Thenard asserts, no acetous acid is obtained, but an acid which is nothing but the muriatic. In fact, it forms with the nitrate of silver a precipitate insoluble in an excess of nitric acid; with soda it forms cubic crystals. If sulphuric acid be poured upon these crystals, a penetrating gas is disengaged, which on being brought into contact with the air, gives rise to vapours; the same acid mixed with nitric acid dissolves gold; with the oxyd of mercury it forms a volatile salt; with potash a salt capable of being fused without undergoing decomposition. These circumstances, according to Thenard, render it probable, that Crell employed the potash of commerce, which always contains muriatic of potash, for in repeating this process with pure potash, no acid is obtained, except an almost imperceptible quantity of vinegar. This vinegar is formed by treating the fat with potash and the sulphuric acid, for fat contains no acid, according to this chemist, not even when it is rancid; at least he has several times treated rancid fat with water, and uniformly obtained a liquid, which did not reddens the tincture of turnsol.

Recapitulation.

According to Thenard, these experiments prove what he has already advanced, viz. that there exists in the pro-

duct of distilled fat a peculiar acid, which, instead of being volatile, odorous and suffocating, is, on the contrary, solid, inodorous, and fixed to a certain degree; that besides this acid, the product of distilled fat contains acetic acid; that the sebacic acid has no share in producing the smell of distilled fat, which probably depends upon some particles of fat converted into vapour, and altered in their nature. They prove, besides, that by the processes of Crell, and by that described in the chemistry of Dijon, the muriatic, or the acetic acid, is only obtained; that consequently, the sebacic acid has hitherto remained unknown, and that in the present state of our knowledge, it is a new acid.

Thenard observes, that all the experiments he made was with hog's lard, and that he has not, like Crell, varied them with human fat, the marrow of the ox, and tallow. He concludes, by proposing to repeat them with these different fatty substances; but expects to obtain similar results. He has not yet examined, he says, all the properties of the sebacic acid; but intends to investigate them with care.

For a more exact determination of the affinities of this acid with other substances, both in the wet and dry way, a nicer examination of the degrees of solubility of it's earthy, saline, and metallic neutral salts, in water, alcohol and other fluids; a further investigation of it in it's gaseous state, and a future proof, whether, like most acids, it forms, with lime, a body which emits light in the dark, must be left for future experiments.

Franc. Gruetzmacher, *Dissertat. de Ossium Medulla*. Lipsiæ. 1748.—Jo. Andr. Segner et Dan. Henr. Knappe, *Dissert. de Acido Pinguedinis animalis*, Goetting. 1754.—Macquer's *Chymisch. Woerterbuch*, von Leonhardi. t. 2. p. 207. *Fettsaure* Leip. 1701.—*Philosophie Chi-*



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#### ZOONIC ACID.

**Zoonicacid.** At the article flesh, it appeared, that Thouvenel had  
 mentioned a saline substance, which, most probably;  
**Discovered** is the acid discovered by Berthollet, by the name of the  
**by Berthol-** zoonic. It is well known, that the liquor extracted by  
**let.** distillation from animal substances, only appeared to  
 contain carbonat of ammonia, and an oil; but Berthollet  
 having detected this acid in it, looks upon it as a pro-  
 duct of the distillation of all animal substances.

**Method of** In order to separate this acid, the oil is first taken off,  
**procuring it.** and lime is then mixed with the liquor of distillation,  
 and the mixture boiled or distilled. The carbonat of am-  
 monia then exhales, and when the smell ceases to be irri-  
 tating, the liquor is filtered, a little more lime is added to  
 it, and it is again boiled, until the odour of the ammonia  
 intirely disappears. What remains is zoonat of lime,  
 which is again to be filtered. Water impregnated with  
 fixed air is then to be poured upon it, or respired air is to  
 be passed through it by means of a tube, to precipitate, by  
 the carbonic acid, the lime held in solution, in an un-

combined state. In order to obtain the zoonic acid pure from the *zoonat of lime* remaining, the water of the *last*, well concentrated, is to be mixed with some phosphoric acid, put into a tubulated retort, and distilled. The zoonic acid being very little volatile, requires a degree of heat approaching ebullition, to make it pass over, so that the liquor must be boiled; if two flasks are adapted to the retort, none of it passes into the second. It appears, that in this process, one portion of the acid is destroyed by the action of the heat; for the liquor, during its state of ebullition, becomes brown, and towards the end of the operation, blackish; hence it may be concluded, that this acid contains carbon. Berthollet did not collect the other principles which are disengaged during the decomposition.

The zoonic acid has an odour resembling that of flesh which is roasted brown, and in reality is then forming. <sup>It's properties.</sup> Its flavour is austere. It reddens very deeply paper tinged with litmus. It effervesces with alkaline carbonats. It did not appear to form crystallizable salts, with alkaline earthy bases. It forms a white precipitate in the water in which acetite of mercury has been dissolved, and in that of nitrat of lead, so that it has a greater affinity to the oxyd of mercury, than the acetous acid, and to the oxyd of lead, than the nitrous acid has. On the nitrat of silver it only acts by compound affinity; but the precipitate, in time, becomes brown, which indicates that the precipitate contains hydrogen. The *zoonat of potash*, when calcined, formed no prussiat of iron with a solution of that metal.

There separated from some flesh which Bethollet had kept for a long time putrid a liquor which gave all the properties of acidity, but which was an ammoniacal salt with excess of acid. This acid, combined with lime, appeared similar to the *zoonat of lime*; but he had not a

sufficient quantity to prove exactly it's identity with the zoonic acid.

Trommsdorf has reason to think, that the zoonic acid is nothing but the sebacie; but he has not proved it by experiment.

Thenard, having examined the zoonic acid, thinks he has demonstrated that it is nothing but the acetous acid combined with a peculiar animal matter. It appears, however, that a further investigation is necessary before the real nature and properties of this acid can be well understood.

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Notice sur un Acide retiré des Substances animales, ou acide zoonique, par le Citn. Berthollet. An. de Ch. No. 76. p. 86. 30 Germinal. An. 6.

## POISONS.

ANIMAL poisons may be divided into two classes.

1st. Those which are produced by animals in a state of health, and are employed as a means of defence, such as the poison of different species of serpents, and insects. Their division.

2d. Those which are produced by an animal in a state of disease, and are communicated to other animals by means of what is called contagion, such as the poison of the cancer, the hospital fore, the venereal virus, that of the small-pox, measles, and the miasma that arises from the putrefaction of organized substances; but as the little knowledge which chemistry affords us of the nature of this class, is to be found at the articles *pus* and *miasma* the present will only contain a description of the few experiments and observations which have been made, to investigate the chemical principles of the first class.

It is to Francis Redi, a celebrated Italian philosopher, Redi. that we are indebted for the discovery of the humour that renders the bite of the viper venomous. The ancients were ignorant of what the venom consisted, and of the part of the animal in which it resided. Redi was the first who established these points. In his treatise on the venom of the viper, it appears, that he found it to be a humour resembling the oil of sweet almonds, which the animal conveys with his tooth into the wound it makes by biting; but he was mistaken in almost every thing else he said on the subject of this poison.

Mead is the first who in any way examined the nature and qualities of it; according to this physician, the venom is acid, as he informs us it changed the dye of litmus red, and even gave a reddish tinge to the sirup of Mead.

violets. A few years afterward, he retracted every thing he had advanced on the acidity of this liquor, and confessed it was neither acid nor alkaline.

James.

Dr. James, who assures us he repeated the experiments of Mead, found it to be likewise acid; but most probably he was ignorant of the latter experiments of that physician.

Jussieu.

Jussieu, persuaded likewise of the acidity of this venom, upon the authority of Mead, immediately found a specific against it in the volatile alkali; he was not, however, the first to recommend it's use.

The uncertainty and contradiction of the fact of the acidity of this poison invited Fontana to investigate the truth of it; and, "I hope" says he, "that there will be no longer any doubt, for I flatter myself to have discovered the error into which Mead happened to fall when he first examined this venom, an error against which Doctor James was not able to guard."

He found, though but very rarely, that the venom of the viper gives litmus a light red colour; but in these cases it was not very pure, as he discovered by the microscope some globules of blood floating in it, and on examining the mouth of the viper, he found the two bags or sheaths that cover the teeth slightly inflamed. It appears, that it is not uncommon to meet with these animals naturally in this state, and it is still more common to find the bags reddened after they have bitten. The venom is also frequently stained with blood if it's receptacle be too strongly compressed. All these circumstances may take place, and in all of them the litmus may be by these means reddened, without supposing an acidity in the venom. It is therefore, according to Fontana, not unlikely, that Doctor James had been deceived in the same manner as Mead, for it is certain, that in the few cases in which Fontana found the colour of the litmus reddened, the venom was not pure, but mixed with blood.



According to Fontana, the venom of the viper, when Fontana. pure, appears, when examined by a microscope, like an oil, of a more or less yellow colour. It is contained in a vesicle for it's reservoir, which is enclosed in a constrictor muscle, situated in the jaws of the animal; by this muscle the liquid venom is squeezed out through an elliptical orifice at the point of it's canine teeth.

It is perfectly tasteless, but leaves on the tongue a sensation of torpor or stupefaction on the part it touches; Properties of the poison of the viper. the tongue particularly feels numbed; it even appears to be grown larger, and it's motions are slower and more difficult.

It neither reddens the tincture of litmus nor the blue juice of radishes.

In a liquid state, it unites more or less with acids.

When dry, they have no effect upon it, except that of making it somewhat tenacious.

Alkalis have no more effect upon it than acids.

Boiling water immediately dissolves it, and loses no part of it's transparency.

Alcohol has no effect upon it,

It is not acted upon by essential oils, or by hepar sulphuris.

It does not melt when exposed to the fire.

Cast upon a red hot coal, it swells and puffs up, but does not begin to inflame till it has assumed the appearance of a coal.

From observing that the dried venom appeared to be tenacious, like one of the strongest gums when broken between the teeth; and that it was also soluble in water, and not in alcohol, Fontana suspected it to be a gum; another experiment, however, remained to render this suspicion decisive.

It is known, that gums dissolved in water are precipitated by spirit of wine, and the water becomes white.

Fontana, therefore, put equal portions of water into two small glasses; he added to one of them a quantity of the venom, and to the other an equal quantity of gum arabic. The solution of the gum arabic, which was effected by heat, being reduced to the temperature of the liquor in the other glass, several drops of alcohol were poured into each of the glasses. Immediately a whitish cloudiness appeared in both solutions, at every drop of alcohol, and disappeared the moment after. On continuing to add an equal quantity of alcohol to each glass, the white cloud, instead of disappearing, extended over the fluids, which became whiter and more opaque on every addition of alcohol. On ceasing to add more, the white matter began to precipitate, and a few drops more caused a perfect separation. At the end of 24 hours the precipitation was complete, and at the bottom of each glass was found nearly the same quantity of an equally white, soft, and paste-like substance.

A drop of venom dried upon a glass cracks, on drying, from the circumference to the centre, and when dissolved in water, and precipitated by alcohol, falls down in the form of a white powder or meal; this if dried afresh cracks in different parts, and its fissures are of the usual reticular form.

If clear and transparent vitriolic acid be mixed with the precipitated and dried venom, at the end of a certain time, it becomes of a dark vinous colour. The same changes are observed in the solution of gum arabic in water precipitated by alcohol. This gum, in drying, likewise adheres to the glass, and cracks; and if a few drops of vitriolic acid be added, they become, in the same space of time, of a dark vinous colour.

The analogy, therefore, between the venom and the gum, according to Fontana, cannot be more perfect. They are both soluble in water, both precipitated in the

same way by alcohol ; the precipitated powder or meal is of the same colour ; both of them crack on drying ; vitriolic acid does not soften them till after some time, and the colour is changed in the same manner with each of these substances. As a further proof that this venom has a great analogy to the gums, Fontana made another experiment. He put six grains of very pure dried venom into a small matrafs, and added 50 drops of nitrous acid. By the assistance of heat there arose as much air, or perhaps more than the matrafs could contain. This was common air somewhat changed in it's qualities. The heat being continued, a clouded air arose, which on examination was found to be composed of one third of fixed, and two thirds of phlogistic air.

Gum arabic under the same circumstances likewise afforded fixed and phlogistic airs, and the results of both experiments were so perfectly similar, that they might have been confounded together. According to Fontana, gum arabic likewise affords nitrous air, but this only happens when in considerable quantity. If the quantity be very small, the little nitrous air it affords is decomposed, and unites to the common air in the matrafs.

Hence Fontana looks upon the venom of the viper to be a real animal gum, possessing all the properties and principal characteristics of a gum, and the only one of the animal kind that is at present known. An animal gum.

From the experiments and observations of Dr. Russel, Russel. it appears, that the poisons of the different species of serpents are very analogous to each other.

When first emitted, they are somewhat mucilaginous, but become more so on exposure to the air ; the colour, from a pale yellowish white, becomes more yellow, and when dry, they resemble a yellow flaky resin. Kept for some time their colour becomes darker, and they lose somewhat of their solubility ; for when recent, according to this

physician, or in the intermediate degrees of exsiccation, they readily mix either with water or spirit. He informs us, that a drop or two of the poisons of the serpents called the Cobra de Capello and Katuka Rekula Poda had no taste, nor produced any effect on the tongue or palate, and that when investigated with the usual tests showed no indication of being either acid or alkaline.

Two drops of the recent poison of the katuka rekula poda, diluted with four drops of spring water, were put into a wine glass, No. 1; and six drops of water into another glass, No. 2; into each glass was then permitted to fall a tea spoonful of blood from the neck of a chicken, just decapitated. Both mixtures being stirred for five minutes, with smooth sticks, were left to settle. The blood in No. 1 appeared of a colour considerably darker than that in the other, and a clot was found adhering to the point of the stick, of a darker colour, and more grumous consistence than ordinary. To the stick belonging to No. 2 a much smaller clot adhered, of a brighter colour, and more loose contexture. After standing three hours, the difference was more remarkable; the blood in No. 1 remained uncoagulated, and much blacker, with a little livid coloured serum above; in No. 2 it nearly retained it's primitive colour; the crassamentum was formed, and a little serum of the usual colour remained at top. On repeating this experiment, the glasses were carefully warmed, and the mixtures stirred only one minute. Very little blood was found adhering to the sticks. The same alteration in colour was observed as before; but the blood in No. 1 was less fluid than in the former experiment, though still much more so than in the glass No. 2.

Before the experiments of Fontana, no chemist had examined with any attention the liquor with which those insects are provided that wound with a sting, such as the scorpion, bee, wasp, &c. Indeed Mead says, he found

the humour of the bee to be composed of very fine saline needles or points; he assures us he had examined it with a microscope, and found it full of these pointed salts. Fontana has, however, proved, that Mead was as much mistaken in these observations as he was in his experiments on the venom of the viper.

We are informed by Fontana that the poison of the <sup>Venom of the bee.</sup> bee, like that of the venom of the viper, cracks on drying, and presents the usual sharp and regular fragments, which were sufficient to persuade Mead of it's being a real salt.

When the venoms of the viper and the bee are dried and examined through the lens of a microscope, no sensible difference is to be observed between them; he however found that the venom of the bee, exposed to the open air upon a piece of glass, was much longer in drying than that of the viper, and that the cracks and fissures in the former were formed much later than those in the latter, supposing the degree of exsiccation of the two fluids alike.

These two poisons not only agree in the appearances their parts present in drying, but likewise in other properties. Thus, if a piece of the dried venom of the bee be strongly compressed between the teeth, it glues them as it were fast together; and the same takes place with the venom of the viper and all exsiccated gummy substances.

The dried venom of the bee is also soluble in water, and resists the action of alcohol like them; hence Fontana is inclined to add the venom of the bee to the class of animal gums, but the quantity capable of being collected he found so very small, as scarcely to render any experiments on this subject certain.

This celebrated philosopher has likewise examined the <sup>Of the scor</sup> poison of the scorpion, which is acrid and pungent, and <sup>tion.</sup>



also that of the wasp, and other insects in general, that wound with a sting. In all these he found this humour to have a hot, bitter and acrid taste, and to possess all the characters of a gum. It cracked, when left to dry on glass, like that of the viper, and when chewed was tenacious, glutinous and elastic.

The humour, however, of these insects, is not to be considered as the same as that of the viper, and to possess all its qualities. It has been observed before, that the venom of the viper has neither any sensible taste, nor is sufficiently acid to tinge red the tincture of litmus, although so sensible is this test, that  $\frac{1}{22380}$  part of a grain of fixed air is able evidently to redden one grain of the dye of litmus. The moment, however, the humour of the insect is applied to a piece of paper stained with radish juice, a slight red tinge appears, which afterwards changes to a pale yellow; so that it appears this humour is united to an acid principle, although in such a manner as not to occasion the smallest acid sensation on the organs of taste.

From the experiments of this chemist, therefore, we are led to regard the hypothesis of those physicians who have advanced that the venom of the viper is an acid, and that volatile alkali is a specific remedy by neutralizing the acid, as false and erroneous, and that these poisons act on the body of animals in a manner which is not at present within the reach of the human mind to penetrate.

Sur les Poisons et sur le Corps Animal, par M. Fontana, 2 T. 1781.—An account of Indian Serpents, &c, by Patriek Russel, M. D. F. R. S. fol. London, 1796.

## AROMATA.

THE small volatile particles which are constantly flying off from animals and animal substances at the common temperature of the atmosphere, and which affect more or less the organs of smell, constitute what are called animal odours or aromata. These aromata, on subjecting these substances to a gentle distillation, generally come over along with the aqueous portion; there are, however, a few in which the want of volatility of the odorous particles oblige them to remain in great measure behind. In living animals the aroma forms the scent of the particular species, and is the means by which the huntsman is enabled to pursue his game, and the dog to trace the footsteps of his master. It was even the opinion of Vitiotti that not only every animal has its peculiar odour, but that it is different in each of its parts. In some bodies it is so very evident as to form a distinguishing character, in others the nicest and most experienced organs are scarcely able to find a difference. It is often made use of as the means by which connoisseurs are enabled to judge of the slightest imperfection or taint of the substance under examination, whether of the different tribes of animals, or of parts of them which have been preserved, as bacon, cheese, &c. from which it would appear that these odorous particles depend upon the peculiar component parts of the animal matter. In certain parts of some animals this aroma seems to be more particularly concentrated, and appears to have been either secreted for some unknown particular purpose, or is merely an excrement; of these there are four which have undergone some slight chemical investigation, viz. *Ambergris*, *Castor*, *Civet* and *Musk*, all of which are the products of the mammalia class. The strong, tenacious, aromatic odour which constitutes

Animal  
aroma.

the more remarkable characters of these substances, appears, however, not to be peculiar to them alone, but seems as it were to form a *genus of aromata* in nature, since many substances offer one analogous to them, more particularly resembling that of ambergris and musk. It is found in some insects, and in a number of the labiated plants, and the laboratories of chemistry, where animal substances have been analyzed, often give occasion of observing the very same aroma. Morveau has observed also, that urine when brought to an extract, the salts of urine when moistened, and the human bile and that of the ox, when kept for a certain time, emit an odour of this species so strong as to have deceived several people, who could not believe the origin of these singular perfumes. Likewise in bilious diseases, the perspiration has been sometimes found to possess this odorous character. The dung of the cow, Morveau informs us, has the same property, and by distilling alcohol upon this excrementitious matter, an aromatic liquor is prepared by the name of *cau de mille fleurs*. It would appear that this odour, whether naturally or artificially procured, is owing to some principle which chemistry is yet ignorant of.

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#### AMBERGRIS.

Amber-  
gris.

AMBERGRIS is a concrete matter of a soft and tenacious consistence like wax, or solid and breaking like the gum resins; it is of a gray colour marked with yellow or black spots, and when heated or rubbed, has an agreeable and peculiarly strong aroma, which, however, to some people is unpleasant. The older it has been kept the more agreeable is the aroma, and its consistence, according to Swediaur, depends upon its having been exposed to a more or less warm air. It is called by the later

Greek writers, *ambar*, by the Latins *ambra grisea* or *ambarum*; and sometimes, as Fallopius has written it, *ambraca*. It is called by the French *ambregris* or *ambre*, and by the Germans *ambra* or *grauer ambra*.

Under the title amber the ancients comprehended another substance, very different in it's nature and properties from this. It is known by the name of *yellow amber*, and is a species of bitumen; it was called by the ancient Greeks *ηλεκτρον*; by the Arabs *karabe*; by the Latins *ambra flava* or *succinum*; by the French it is named *ambre jaune*, *citrin* or *succin*; and by the Germans *agtslein* or *bernstein*.

Naturalists have distinguished several varieties of *ambregris*. Wallerius mentions six.

- |                                |                                |                         |
|--------------------------------|--------------------------------|-------------------------|
| 1. Ambergris with yellow spots | } These are the most precious. | Varieties of ambergris. |
| 2. ————— with black spots      |                                |                         |
| 3. White.                      |                                |                         |
| 4. Yellow.                     |                                |                         |
| 5. Brown.                      |                                |                         |
| 6. Black.                      |                                |                         |

These varieties depend on the mixture of certain marine substances which they contain. It is found in irregular, sometimes globular masses, consisting of strata of different kinds, and more or less thick according to the number united. Pieces have been found of more than 200 lb. weight. It has evidently been in a liquid state, as it envelops many foreign matters, such as squids, or the bones of the cuttle and other fish, fossil shells and other marine bodies.

It is found floating on the sea near the Molucca Islands, Madagascar and Sumatra, likewise on the coasts of <sup>Where found.</sup> Coromandel, Brasil, and on those of Africa, China and Japan. It is seldom found in large pieces, although it is related that Lockner saw one of 42, and Kæmpfer another that weighed 130 pounds,

The state of analysis of this substance is very imperfect; some experiments were made upon it many years ago by <sup>It's distillation.</sup>

Geoffrey, Neumann, Grim and Brown, but they are very imperfect. We learn from them, that the strong aroma of ambergris is communicated to the water which arises on distillation: that in a moderate heat, it melts like wax, and then resembles a thickish blackish oil, exhales vapours, foams, and at length entirely evaporates; that in the flame of a candle it inflames and burns away with a clear flame. By the dry distillation it affords a sourish water, a little fixed salt, and some oil.

According to Hagen, it is not soluble in water but is in alcohol, and still more so in the vitriolic æther.

A more exact analysis of ambergris has been made by Vauquelin and Bouvier upon a variety sent them by Macquart. This was the *black* variety. It was composed of strata of different colours and thickness. In certain parts, white crystals were evident; they were isolated. Its odour was strong and disagreeable, resembling in some respect the urine of the mare; this was more particularly so with the salt obtained by the evaporation of this fluid. It was specifically lighter than water.

Water.

Fifty parts of this pulverized ambergris were boiled in two oz. of distilled water for 10 minutes, the odour which arose was much less disagreeable than that from the solid substance. It tinged the water of a deep straw colour; at 60° it melted and swam upon the surface, and was of a semipellucid brown colour. The filtered liquor produced no change upon sirup of violets. On evaporation, nearly two grains of a yellow product were obtained of a sharp and saline flavour, mixed with crystals of common salt. The solution changed the sirup of violets green.

Alcohol.

Boiling alcohol dissolved a great part of the residuum, became of a deep brown colour, and the black grumous matter remaining, being treated a second time with alcohol, became yellow, but it did not dissolve it. The resi-



duum, which was almost entirely formed of membranous matter, dried and put on red coals, produced a yellow, fetid, ammoniacal smoke.

On cooling, the alcohol deposited a great part of what it had taken up.

A portion of this residuum on distillation afforded a red oil extremely fetid, and exactly similar to that of other matters, and some carbonat of ammonia.

From it's treatment with alcohol, it appears that the aromatic part does not reside in the resinous part of the ambergris. The brown membranous parts of it presented many of the characters of animal matter, although their coal being not light, made them approach to the algæ which have some resemblance to animal matters. Are they therefore, it has been asked, animal membranes, or remnants of the fuci?

The crystals found in the ambergris appeared to be a mixture of sand and calcareous earth.

Oxygenated muriatic acid poured upon a portion of the Oxygenated muriatic acid. alcoholine resin of the ambergris, took away it's brown colour, but did not perfectly whiten it; it remained yellowish and lost it's odour, and the same happened to the acid. It's consistence however was not changed.

Well rectified ether dissolved the greatest part of the Ether ambergris, which had been previously treated with boiling water. The residuum was black and grumous, but afforded no pellicles, as was the case with the alcohol. The spontaneous evaporation of the ether from the resinous part weakened the odour of the residuum by raising it into the atmosphere.

Thirty parts of oxyd of silver and three parts of the Oxyd of silver. resin, by a gentle heat, afforded from six to seven inches of carbonic acid gas, without any mixture of hydrogen gas. In the tube of the apparatus several clear and transparent drops of water were observed, and the silver being re-

duced weighed 21 grains. This experiment upon larger quantities might perhaps give the proportions of the principles of this resin, or at least of the hydrogen and carbon which form it's basis. It might be even possible to come at it's quantity of oxygen by exactly knowing that of the oxyd of silver.

Exposed to  
fire.

Thirty six grains of this ambergris exposed to the fire in an open crucible soon became soft and melted; on increasing the heat a few degrees, it inflamed; the flame was at first yellow and white, and the smell disagreeable. The smoke soon ceasing, the flame became more clear and brilliant, with an odour resembling that from burning mastic or olibanum, depositing carbon extremely divided, as is the case with odorous substances. The residuum was three grains and a half of white matter in very distinct hard grains, the greater part of which was sand and carbonat of lime.

No more traces were found of carbonat of soda or common salt, and these chemists seem to think that they were volatilized by the heat, since the edulcoration of the ambergris afforded them by a gentle evaporation.

Use.

Ambergris is employed in medicine, but it's greatest use is as a perfume mixed with musk, the aroma of which it so attenuates as to render it milder and more supportable.

Characters  
of pure  
amber-  
gris.

As this substance is very dear, it is often falsified and mixed with different substances. The real ambergris has the following character: it is flaky, insipid to the taste, of a sweet odour; exposed to the flame of a candle in a silver spoon it melts without scum or bubbles. It floats upon water, and does not adhere to a red-hot iron; that which does not possess these properties is adulterated and impure.

## ORIGIN OF AMBERGRIS.

NATURAL historians and chemists have been very much divided respecting the origin of ambergris. The greater number have looked upon it as a bitumen, a sort of petroleum, that issued from the rocks, and was condensed by means of the sun and the action of the salt water. Cartheufar made no doubt of it's being of this nature, and what confirmed him in this opinion was the analysis of it by the chemists, particularly by Neumann, who got the same component parts from it as from amber, viz. phlegm, a volatile acid, partly fluid, partly fixed, an oil, and a little carbonaceous matter. Macquer, however, observes, that it differs from common amber by being far less hard, and not smooth or able to take any polish; it is likewise opaque and fusible; that it is also rendered softer even by the heat of the hand, like wax. Likewise on distillation it leaves much less carbonaceous matter, from which it appears to him to be of a much more oily nature than common amber. Different opinions.

Ambergris has been likewise supposed to be of vegetable origin. Aublet affirms, (*Histoire des Plantes de la Gujane*, 1774) that it is nothing but the juice of a tree in Guiana inspissated by evaporation; that this tree is called cuma, and by Linnæus, *amyris ambroisiaca*; that the river washes pieces of it into the river, that Rouelle has examined many of these pieces and found them to agree perfectly with ambergris in their properties. Rumph has also noted a tree called *nanarium* which affords such a juice. Bergman was also of opinion that it was of vegetable origin. Pliny in old times was of the same opinion. Aublet.

Some, on the contrary, have supposed it to be the excrement of birds that live upon odoriferous herbs, and

Pomet and  
Lemery.

others have attributed it's origin to the matter rendered by the sea cow, or the excrement of the crocodile, &c. Pomet and Lemery believed it to be a mixture of wax and honey roasted by the action of the sun; and Fourcroy, who adopted the same opinion, says, that a product very analogous to that of ambergrease may be obtained from these two substances.

Swediaur.

Some English authors have looked upon it as an animal juice deposited in sacs placed near the organs of generation in the male whale; and others, think that it was formed in the urinary bladder of that animal; but both these opinions are contradicted by the beaks of the cuttle fish being found in this concrete juice. At length, Dr. Swediaur, a Swede, after having examined a great number of specimens of ambergrease, and the accounts of several navigators, looks upon it to be formed in the alimentary canal of the physeter macrocephalus, a species of whale from which the spermaceti is extracted. He considers it as an indurated excrement mixed with certain parts of it's aliment, on a kind of bezoard of this cetaceous animal. He grounds his opinion on the following circumstances:

- 1st. Because fishermen find ambergrease in this whale.
- 2d. Because ambergrease is common in those regions frequented by this whale.
- 3d. Because the beak or chops of the sepia octopodia on which the animal feeds is always found in it.
- 4th. Because he discovered the black spots in this concrete substance to be the feet of this polypus.
- 5th. Finally because the excrements of several quadrupeds, such as cows, pigs, &c. after being kept a certain time exhale an odour analogous to that of ambergrease.

The inquiries of this physician have rendered this opinion of the Japanese and of Kæmpfer very reasonable; and nothing, says Fourcroy, is wanting to it's entire confir-

mation, but the observation of some real naturalist made upon the spot.

It has been seen, however, that this substance, analyzed by Geoffroy, Neumann, Grim, and Brown, afforded the same principles as bitumens, *i. e.* an acid spirit, a concrete acid salt oil, and a carbonaceous residuum, which induced them to rank it amongst those bodies. To this Swediaur observes, very truly, that the calculi of animals likewise afford an acid, and that the presence of this salt is a proof in favour of his opinion, since fats contain it also in considerable quantity.

This physician has likewise been informed by several American fishermen, that they have found ambergris very often, either amongst the excrements of the physeter macrocephalus of Linneus, or in it's stomach, or in a pocket, which they say is situate near the viscera, probably the cæcum.

In support of the opinion of Swediaur, it may be added, that according to the testimony of Coffin, who was examined before the committee respecting ambergris, it appears, that the spermaceti whale, who lives on this polypus, or what the sailors call squids, evacuates his excrement on being struck with the harpoon; and if this does not take place, they conjecture there is some ambergris in his belly, looking upon this substance to be either the cause or effect of disease. Such are the reasons why this substance may be ranked amongst the resinous and odoriferous matters of the animal kingdom.

In opposition to the opinion of Swediaur, Dandrada, <sup>Dandrada.</sup> a Brazilian, published an account of the origin of this substance; who, after having observed, that it is only upon account of the chops of the cuttle-fish, that Swediaur has founded his opinion, thus continues his narrative, which is extracted from Fourcroy's account in the Encyclop. Méthodique.



“ Kämpfer thought, after the Japanese, that ambergris was an excrement from the whale ; and the opinion of Swediaur is only a modification of it. The natives of Brasil, at the time of it's discovery, were of the same sentiment ; but whoever will take the trouble to examine the grounds on which it is supported, and the places where it is found, will be convinced of the contrary.”

If ambergris was the excrement of the diseased whale, it would be found in all the places where it frequents, but on the contrary, it is only found on some shores of the warmer climates, as at Madagascar, the islands of Cape Verd, Japan, China, the Brasil Islands, &c. In this last country, it is only to be met with on some of the shores and bays, principally at the mouth of the river Camouci, in the precincts of the territory of Maragnon, and in the bay of All Saints. From 20° of south latitude, to the river Plata, it is never met with. Now, it is at Santo, the country of Dandrada, situate at 24° of south latitude, and at Santa Catherina, still more to the south, that the whale is caught.

According to Dandrada, ambergris is not an excrement, since, at Brasil, it has been several times extracted from the stomach of the whale.

Magalhaens Gandavo affirms in his history of Brasil, printed at Lisbon in 1576, that some whales had been dissected on purpose, and that pieces of ambergris had been found in the stomach of one of them, and some in the intestines, that were become more soft. All this is lately confirmed in the *Courier de l'Europe*, for the 11th of January, 1791, which relates, that the vessel, the Lord Hawkesbury, had lately caught a whale, from the œsophagus of which, it is said, 400 ounces of ambergris have been extracted.

Besides, if it was an excrement unnaturally hardened, as is the opinion of Swediaur, it would neither be found

in strata, which are almost always horizontal, of unequal size, and sometimes even different in their nature. It is observed by Bomare, that the ambergris he examined, from the east, was composed of strata, of which the second was inodorous, calcareous, and saline. If there are some pieces that have spots, and the chops of the cuttlefish, there are likewise many that are homogeneous, and without spots; and even Pelletier showed a piece, at one of the sittings of the Society of Natural History, at Paris, that contained some small shells. It is probable those pieces that contain the beaks, are the same that had been swallowed by the whale.

Why, asks Dandrada, are they only found on the shores after tempests? and why are not the other hard excrements of the same fish found at the same time? and why is it only soft ambergris, and without consistence? That of the shores is likewise less coloured than that taken from the whale, which ought to be the reverse, according to Swediaur's opinion, since this must have been exposed a longer time to the heat and light.

It is related by an author of an ancient Portuguese manuscript, on the most remarkable things of Brasil, for the year 1680, that one of his friends, Antonio Gil, had shown him a marine spring in the island of Taparica, in the bay of All Saints, which, when the sea was low, appeared visible, where he had seen ambergris spring up and increase between the rocks near it. Simoneus de Vasconcello, superior of the Jesuits of Brasil, affirms, in his introduction to the chronicle of that province, printed at Lisbon, in 1720, that at Taparica fossil ambergris was to be met with. Now, all these observations and authorities, says Dandrada, are absolutely contrary to the hypothesis of Swediaur.

The analysis of Geoffroy, Neumann, Grim, and Brown, although imperfect, constantly afforded them the

same liquid and concrete acid, some oil, and charcoal; but if ambergris was an excrement of this fish, it ought to have afforded ammonia, and other products of animal substances; for all the other excrements of the mammalia tribes afford it. These chemists likewise say, that the acid they obtained from it was the same as from bitumens, *i. e.* the succinic acid. Some chemists affirm it to be of animal origin, from it's odour; but this odour, unfolded by the action of air and light, and which increases by age, must not be confounded with that of the bile, the calculi of which are round, and crystallized in concentric strata. This hypothesis may likewise be defended by the observation of Romé de Lisle (Journ. de Phy. v. 2. 1784) who says, that the sepia octopodia, Lin. or the polypus octopus of Rondelet, was called by the ancients, according to Rondelet, eladone, d'ozaina, and d'osmylus, because this kind *smells well*. That the modern Greeks call it moschytis, because it smells like *musk*, and not only when alive, but when dead and dried.

Now is it not infinitely probable, says Romé de Lisle, that the musky odour of this polypus contributes to form that of the ambergris, because it is found in whales that eat this kind of polypus; and that ambergris, or at least it's odoriferous basis, arises from this digested polypus? But Dandrada observes,

1st. That this appearance, from what has been said, is not probable.

2d. That it is necessary to distinguish this musky odour from that of the ambergris.

3d. That as this polypus affords a very black colour, it would undoubtedly blacken all the pieces of ambergris.

4th. That at Brasil, where ambergris is found, these polypi are very rare, and on the contrary, they are very abundant in other parts frequented by the whale, where no ambergris is to be found.

But what, says the same author, is the nature and origin of ambergris? After what has been said, and considering the property which it has of adhering to the knife when cut, like wax, and soft bitumens, and from it's inflammability, and fusion into a thick and blackish oil, it appears, says Dandrada, we may run the hazard of saying, that it is a kind of submarine bitumen, peculiar to warm climates, which being thrown by the waves on the shore, becomes hardened; that this bitumen is sometimes swallowed by the whale, and others of the cetaceous tribes, which not being able to digest it, part with it more or less changed, along with their other excrements. That the ambergris found by Donadei, on the sea shores on the coasts of Guinea, which was soft and viscous, and of an odour which he called strongly resinous, and which it lost after a certain time, and becomes solid, is not against my opinion, it came from the islands of Cape Verd, or the Canaries, as well as the pumice-stones of these islands, to be met with on the coasts of Gascony, and which have been driven there by the currents of the ocean and Mediterranean. The complete analysis of this substance, and the more numerous observations which I intend to make at the Brasils and the islands of the Cape, may, perhaps, put this matter in every possible light.

This celebrated chemist contends, that in spite of Dandrada's observations and reflections, he is far from having <sup>Fourcroy.</sup> proved that ambergris is a bitumen analogous to amber, jet, or common coal, &c. On the one side, there is too great a difference between this substance and the real bitumens; on the other, too great an analogy between the properties of ambergris and a great number of substances that are odorous, or susceptible of becoming so by successive alterations, to adopt his opinion. It is not so improbable



to think, that even the matter of the body of the *sepia octopoda*, may contribute to it's formation. The Indian ink, which is made, as we are informed, from the black juice of this polypus, affords a very strong odour of ambergris. One of the varieties of ambergris is of a black colour, and very strongly aromatic, it resembles a black thick juice, and animal membranes are even found in it, nor is it rejected by the perfumers.

Ambergris was only known in France, as coming from the two Indies. In the *Journal de Physique*, for May, 1790, Donadei certified that this substance likewise belonged to the coast of Gascony; and it's existence on this coast appeared to him to confirm the researches of Doctor Swediaur, by which he proves that ambergris is an animal production belonging to the whale.

It appears, that Dandrada, in one of the latter sittings of the society, was of a contrary opinion; he supposed it to be a specimen of bitumen arising from some submarine volcano, and consequently he looks upon it as a mineral substance. If this opinion be true, the gulf of Gascony only owes it's ambergris to the islands of the Azores; those of Cape Verd, and the Canaries, tend by very violent currents towards the coast of Barbary. Chemical analysis only can decide this question. As to Fourcroy, he looks upon it as an animal substance.

1<sup>st</sup>. From the urinous odour it exhales when fresh cast upon the coast; it is then pretty soft and viscous.

2<sup>d</sup>. From the avidity with which the sea birds search for it. These live only on fish. The horizontal and various shaded strata of the different pieces of ambergris, cannot be a proof of Dandrada's system; on the contrary, a substance cast into a denser fluid, and which does not dissolve in it, cannot form any horizontal strata; and this is not the case where this substance may easily increase by



strata: as to their shades, the antiquity of it's strata, and the different places in which the animal has lived, may occasion them.

The shells, the jaws, of the sepia octopodia, and the other bodies found in it, can only be foreign to it's nature, and have been united to it at the edges of the coast where this substance, still soft, is cast about and rubbed by the waves.

Lastly, if uniting the two opinions, ambergris was really a bitumen, which had need of sojourning some time in the body of the whale to acquire all it's properties: the question would be very difficult to resolve; he therefore looks upon it as a sort of bezoar, and the yellow part as having much analogy to the bile. The best ambergris has a gray ground with small yellow spots.

According to Fourcroy, the physical properties of ambergris, and it's analysis, do not indicate that it is of animal origin; they rather seem to announce it to be a factitious composition of vegetable resins, of animal pellicles or membranes, and of a certain quantity of the excrement of some quadruped, particularly that of the horse, to which it's odour is owing, since this odour is the same as that of the salts and extract of the urine of that animal.

From these details it appears we are far from knowing the intimate nature and properties of ambergris, and of determining it's origin with precision. It is for chemical analysis alone to pronounce on this interesting object. Till then, it has been placed, with Hildebrandt, amongst the animal substances.

Hagen von der Auflösung des Grauen Ambers in Vi-  
triolæther, in Crell's Chemisch. Annal. t. 11. s. 99.  
1784.—Casper Neumann, Disquisitio de Ambra. Dresd.  
1736.—Information of the origin of Ambergris. Phi-

lofoph. Tranf. part 1. 1791.—Encyclop. Méthod. article Ambre-gris, by Fourcroy.—Neue Zufätze und Anmerkungen zu Macquer's Chym. Wörterb. von Leonhardi. Erft. B. p.124.—Graue Amber.

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CASTOR.

Castor.

THIS animal fubftance, when freſh and juſt taken from the animal, is foft, and nearly in a fluid ſtate; it is of a yellowiſh colour. By drying in the atmosphere, it aſſumes, in time, a refinous friable conſiſtence, and becomes of a much darker and browniſh colour. In this laſt ſtate it is generally met with at the ſhops. It has an acrid, bitter, nauſeous flavour, and it's odour is ſtrong, aromatic, and even fetid, which it communicates to the water extracted from it.

Examined  
by de la  
Grange.

For the beſt analyſis of this ſubſtance we are indebted to de la Grange; he found, that two ounces of it macerated in water, at the temperature of 60° for 12 hours, became conſiderably ſoftened, and gave the water a pale yellow colour.

This water changed the blue colour of vegetables to a green, and when exſiccated, it was ſoluble in alcohol, efferveſced with acids, and was deliqueſcent.

Having macerated ſome caſtor in water, at 40°, for 24 hours, it divided into an infinity of ſmall particles, the water became whitish, and covered with a brown oily pellicle, perfectly ſoluble in alcohol. Having added one drachm of carbonat of poſaſh in a deliqueſcent ſtate, to four ounces of this liquor, the mixture preſented a very curious phenomenon. It formed three very diſtinct parts, viz. red, limpid, and whitish. Having ſeparated and exſiccated theſe three liquors,

The *red* part afforded a substance of a deep gray colour, one part of which was attracted by the magnet, and soluble in muriatic acid. Exposed in a crucible to a red heat, 12 grains of iron and 6 grains of earth were obtained.

The *limpid* part afforded an alkaline matter that had all the properties of carbonat of potash.

The *whitish* part afforded an earthy substance somewhat alkaline, which earth appeared to be calcareous.

Some castor macerated in water four days in a sand bath, afforded a fluid of a much deeper colour, and on evaporation, a dry extract was obtained of a beautiful tortoiseshell colour. This extract was soluble in alcohol and in sulphuric ether.

From the alcoholic solution was precipitated by distilled water, a resinous substance, swelling and inflaming in the fire. This extract was also partly soluble in water. The liquor changes the blue colours of vegetables to a green, and becomes, according to Fourcroy and Chaptal, a partly extractive gelatinous mucilage.

The muriatic, nitric, and acetous acids, have no action on castor.

If castor be mixed with quicklime, and a little water be added, a lively effervescence takes place, and there arises a very strong ammoniacal odour. Carbonat of ammonia was extracted from it.

Castor decomposes the metallic salts, which, according to de la Grange, is a further proof of it's containing a pure alkaline matter.

It's decomposition by the retort affords nothing in particular. The carbon obtained after the operation, exposed on red hot coals, burns with a flame, and swells considerably. The nitric acid totally dissolves it.

Hence may be obtained from castor, according to this

chemist, carbonat of potash, a calcareous earth, iron, and pure resin, an extractive gelatinous mucilage, a volatile essential oil, and carbonat of ammonia.

Fourcroy.

According to Fourcroy, castor consists of a coloured resinous matter, soluble in alcohol or ether, together with a gelatinous mucilage, and an extractive matter, taken up by water; and likewise a solid, which crystallizes in the aqueous solution by evaporation, but the nature of which has not yet been examined. The resin of castor, in which it's whole virtue resides, appears to be analogous to that of the bile. It has not yet been accurately analyzed; it is only ascertained that it affords a small quantity of essential oil, and volatile alkali by distillation; and that the several matters of which it is composed, may be separated by means of ether, alcohol, and water.

The produce of the beaver.

According to de la Grange, the beaver, or amphibious animal from which castor is extracted, was called by the ancients *fibrum*, the end or extremity of something; and that it is pretended castor takes it's name from the edge or shore of the water where this animal generally lives. Others are of opinion it comes from the greek word *φιβρος*. The Latins called it *Fiber*.

This production, which the beaver affords, is the cause of the continual war which man has waged against this innocent, peaceable, and industrious animal, whose manner of living, and state of society, as Buffon says, is a proof of the great perfection he has attained in civilization, and is described with all the elegance and eloquence of that author.

The castor is taken from the inguinal region, where are to be found four bags of an oval shape, a large and a small one on each side. In the two larger bags is the real castor. The two smaller contain a softer and more unctuous fatty matter, of the same kind of smell as that of castor, which is used by the hunters as a decoy for foxes and

other wild beasts of prey, which pursue the beaver by the scent. It is brought from different countries, but particularly from Poland, Russia, the East and West Indies, and in America, from Canada, more particularly. This last substance is sometimes sold for real castor. Manufactures of this drug are formed in several places, and there is one at Frankfort.

This substance is so well imitated, both as to its odour and form, that without a particular and attentive examination it would be difficult to find out the difference unless by analysis. We are told by Neumann, that the castor of the full grown beaver is preferable to that of the younger, and hence the large bags are the best. From its being so scarce, it is often adulterated. It is usual to open the sacks, and having emptied them, to replace the castor by a composition of dried and powdered blood, gum ammonia, galbanum, wax, resin, &c. with a little powdered castor and the inguinal fat of the animal; they are then glued up again by isinglass so dextrously as not to be detected.

Difference  
between  
true and  
false castor.

According to de la Grange, the real castor has a more penetrating odour, the bags are a little more pointed, and closed above by a ligament enveloped with the fat of the animal; two bags are generally found united by the same ligament. If these bags be opened, some filaments are to be distinguished by a lens, some of which are whitish, others reddish, united transversely. The false, on the contrary, is more widened above, and appears as if sewed, whilst the interim only presents a species of paste, in which a little real castor has been put, but there are none of the filaments to be seen.

Observations sur la Castor, par Mons. de la Grange, Journal de Phys. sem. 1. p. 65. 1792.—Neumann's Chemistry, vol. 2. p. 428. and Fourcroy's Elements.



## CIVET.

Civet.

THE analysis of this substance is very little known. According to Neumann, good civet is of a clear yellowish or brownish colour, of an uniform consistence, like butter or honey; it has a very strong aroma, which is only agreeable when diluted with other substances. It is rarely met with in a genuine state; and there is no certain criterion to distinguish it by.

It unites easily with oils, but not with alcohol or water; it however communicates some of it's aroma to both.

It is used as a perfume, and is collected from the inguinal region of the civet cat, which is met with in the East and West Indies. The civet is squeezed out every other day in summer, and in winter twice a week. The quantity procured at one time is from two scruples to one drachm or more. Thus collected, it is much purer than that which the animal sheds against shrubs or stones in it's native country. Several of these animals have been brought to Holland, and have afforded a considerable branch of commerce, particularly at Amsterdam.

Neumann's Chemistry, vol. 2. article Civet.

## MUSK.

Musk.

FOR the best chemical account of this aromatic substance, we are indebted to Neumann, little having been added to it's analysis since his time.

Examined  
by Neu-  
mann.

Musk is either of a dark brown, or rusty reddish colour; sometimes it is clotted like coagulated blood. To the

touch it is unctuous, and on drying becomes pulverizable. It has a bitterish savour, and it's aroma is peculiarly strong and aromatic, disagreeable if too concentrated, but when largely diluted with other matters, or greatly extended in the atmosphere, it becomes a pleasant perfume. From it's aroma being remarkably diffusive and tenacious, every thing in it's vicinity becomes perfectly infected with it, and retains it a long time. Water extracted two fifths of it, and the distilled water is greatly impregnated with it's aroma and savour; alcohol, took up one third of it, but retained little or nothing of it's aroma. Nitrous and vitriolic acids totally dissolve it, the first destroys the whole of it's aroma, the latter the greater part of it.

Mineral alkali extracts from it the smell of volatile alkali, when these two substances are rubbed together.

Oils have no action upon it. Cast on red hot coals it emits the same fetid smell as urine. On distillation, Neumann obtained the same products as from other animal substances, viz. an empyreumatic oil, a volatile spirit, and salt.

According to Lewis, by impregnating the waters and Lewis, spirits distilled from odoriferous vegetables with a minute portion of musk, their fragrance is considerably improved, without receiving any of it's own peculiar aroma.

According to Fourcroy, it resembles castor in it's che- Fourcroy, mical properties; it consists of resin, united to a certain quantity of mucilage, bitter extract and salt; it's virtues are stronger than those of castor.

Musk is extracted from a bag situate near the umbilical region of a ruminating quadruped, resembling the antelope (*Moschus Moschifer*. Linn.) This bag has no external opening, according to Neumann, like that of the civet cat, and hence the musk is not to be got till after the death of the animal. This chemist informs us, he

Origin of  
musk.

had seen the animal alive, and observed, that the apartment in which it was kept had a very strong smell of this animal aromatic, and that on the white walls against which the animal had rubbed itself, there was an unctuous matter of the same smell.

Two sorts  
of it.

Two sorts of musk are distinguished in commerce; the one is enclosed in the bags, the other is extracted, and each of these is again subdivided according to the countries from which they are brought. Hence arises the Tunquin or East Indian musk, and the Muscovy or Persian musk. The Tunquin bags have commonly small brownish hairs upon them, the Persian large white ones. The former are accounted the best; but the difference seems to be only in the quantity, and not in the quality, the thinner and less having bags containing more in proportion to their weight than the others. From the dearness of this drug, it is often adulterated; and there is no criterion to be depended upon to ascertain its purity. The only method is to compare it with real specimens.

Neumann's Chemistry, by Lewis, article Musk.—  
Fourcroy's Elements of Chemistry.

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## COLOURING MATTER.

BEFORE the examination of the colouring matter of different animals, it may be necessary to take some notice of the action of light upon them.

1. Effects of  
light upon  
living ani-  
mals.

That the human skin, on being for some time exposed to the rays of the sun, changed its natural whiteness to that of brown, vulgarly called freckles or tan, must have been known from the earliest ages. It equally appears that the difference of colour of the human inhabitants of

the globe depends upon the same cause, viz. the effect of light upon the rete mucosum of the skin; and so universal is it's action, that not only the rest of the animals are subjected to it's influence, but it is extended to variegate with different shades even the vegetable part of the creation.

Such being the action of light, it is very evident, that Man. the greater the quantity of light, or the more it is concentrated, the greater will be the effects it produces. Thus, in those countries where the rays of the sun are the most intense, the darker coloured we should expect to find their inhabitants; and hence that blackness peculiar to the negroes and natives of the torrid zone. In some parts of Asia, and in America, and in the southern parts of Europe, we find the colour of the inhabitants varying according to the heat of the climate, from a dark copper colour to a pale tawny; these people being less exposed to the light than the negroes, must necessarily be less dark coloured. If we take a view of the northern countries, which are still less exposed to light, we shall find their inhabitants nearly white, whilst the women of these last countries, and those who have been long confined in the dungeons of prisons, who are the least of all exposed to the light of the sun, are still much fairer, and even have a pallid hue.

The same cause acts on the other animals. Thus we Quadrupeds. find, that the beasts of the equatorial countries are uniformly deeper coloured, or, as it is called brighter coloured, than those which inhabit the polar regions, and some of the northern animals are dark coloured in summer, and white or pale during the winter.

The same with respect to birds, the colours of which are Birds. much darker or brighter under the tropics than those of the north.

Fish and  
Zoophytes.

Fish and Zoophytes, the perceptive inhabitants of the ocean, depend, according to Davy, on similar causes for their colours. He has observed, that these last, when exposed to light, are uniformly brighter coloured than those which have been by any means secluded from it; and he succeeded in changing the colours of two sea anemones from a dark red to a pale pink, by secluded them from the light.

Parts of  
animals.

It is the same with the parts of animals. Thus in Europeans we find the parts of the body exposed to light, darker coloured than those that are concealed. Hence the great attention of the ladies, in those countries where fairness is accounted an accessory to beauty, of covering their necks and faces from the rays of the sun. The hair on those parts of beasts likewise, which is not exposed to light, is uniformly paler than on those exposed to it's influence; and those parts of birds which are not exposed to light are uniformly pale. Thus the feathers on the bellies of birds are generally white; the back, which is exposed to light, is almost always coloured; and the breast, which is partially exposed in most of this tribe, is brighter than the belly, and paler than the back; whilst those parts, even of the same feather, which are exposed to light, are uniformly brighter coloured than those which are deprived of it's influence. The same may be said of fish, the parts of which being exposed to the light, as the back, fins, &c. are always coloured brown, yellow, red, green, blue, &c. in different species, but the belly, which is deprived of light, is found white in all of them. To extend the same observations to plants, it is well known, that in order to bleach or whiten them, nothing more is necessary than to keep them from the light; hence the bleaching of asparagus, salady, lettuce, &c.

Young ani-  
mals com-  
pared with  
old.

To the same influence may be attributed the paler or lighter colour of young animals, when compared with



old. Thus we are informed that negro children when first born are white, and do not become black until after having been a few days exposed to the light, and this blackness is found by observation to be considerably accelerated by early exposure to a strong light. It appears also that the hair of kittens, puppies, &c. though fitted by nature to become black, is immediately after birth of a brownish or dark brown colour, which gradually darkens externally as far as it is exposed to the light, but no farther, for, according to the observation of Bancroft, the blackest cats and dogs, even in old age, have that part of the hair nearest the skin and most secluded from light, particularly towards it's root, only of a brownish black colour, very different from what is seen at the ends or points; and Dorthes affirms that most of the larvæ of insects that inhabit the interior cavities of animals, as well as of earth, fruit, wood, &c. are white, and that having detained many of them under transparent glasses exposed for some time to the light, they lost by degrees their whiteness, and acquired a brownish colour.

To these facts may be added, that Sennebier mentions on the authority of Scheele, that the nereis lacustris is red whilst living in places accessible to the sun's rays, and white in obscurity; and Dorthes found that the tree frog (*rana arborea* Lin.) which generally lives in the shade, being obliged to shift his situation into the sunshine, changes his colour from a yellowish to a very dark green.

Having given some account of the action of light upon animate matter, it remains to show it's effects on inanimate matter. And here the scene changes, for whilst it gives intensity to the colours of living beings, it deprives them of those colours after death. It is thus that in cabinets of natural history, beasts, birds, insects, and even plants, all

2. Effects of  
light on  
dead ani-  
mal

more or less lose their colour, although defended from the air, if they be exposed to the light. This confirms us in the position that agents which hasten incessantly new combinations in living beings, only serve to hasten their decomposition, when deprived of life. It is to the action of light also that the fading of silk arises. We are told by Poivre, that yellow silk taken from the cods, and exposed to the rays of the sun, soon becomes perfectly white, and the same circumstance of natural bleaching happens to ivory and bones after they have become yellow. These effects are similar in appearance to those which occur to white-cotton garments and white lead paint which notoriously become yellow, if deprived of a free access of light for any length of time, but are again rendered white by restoring to them their proportion of oxygen to which they owe their whiteness.

That substances imbibe light has been long observed; for Beccaria informs us, that bones, teeth, bezoars, nephritic and urinary calculi, and egg shells which had been exposed to the sun, gave light in the dark.

Manner of  
action of  
light.

Berthollet.

There have been several opinions with respect to the manner in which the rays of light act upon animal substances so as to give rise to the facts already mentioned. According to Berthollet, these changes are produced in animals by a species of combustion, which from its great slowness is not able to effect a decomposition of the parts so as to amount to their destruction, but only to a destruction of the hydrogen, which as it combines more easily, and at a lower temperature than charcoal does, leaves the charcoal predominant, so that the natural colour of charcoal is more or less blended with that which before existed, and as the light of the sun considerably accelerates the destruction of colours; he concludes, that it ought, if his theory be well founded, to favour the combination of oxygen and the combustion thereby produced.

Dr. Bancroft does not coincide with the opinion of <sup>Bancroft.</sup> Berthollet;

on giving his ideas on this subject, he first attempts to prove, that light will unite with oxygen and separate it from its compounds; hence the revivification of gold, silver, &c. from their oxyds by the contact of light, as Scheele has proved, which, according to Berthollet, is produced by the light separating the oxygen in the form of pure air. Hence a bottle filled with oxygenated muriatic acid, exposed to the light, lets go its oxygen, and becomes common muriatic acid, whilst, if wrapped in black paper and exposed to the sun, it suffers no change; and if heated in the dark, flies off in the form of oxygenated muriatic acid gas without any separation of its oxygen.

Light having therefore this effect on oxygen, it accounts for its action respecting the colours of different substances. Thus the nitrous acid, by being deprived more or less of its oxygen by light, and by letting the azot predominate in a greater or less degree, assumes a variety of colours, as yellow, orange, aurora colour, red; and according to Keir, an orange coloured nitrous acid by long keeping became green, and afterwards of a deep blue; hence we have an example of all the various colours produced by the two species of air that compose our atmosphere, when mixed in certain proportions. This mode of reasoning, Bancroft applies to animal substances. The only thing he thinks, however, to be ascertained on this point is, whether the colours which accompany or require the application of light, result directly from a combination of it with the coloured substance, or indirectly from its particular action in occasioning a separation of airs or their bases (and particularly of the oxygen) or by favouring a combination thereof with the coloured matter. Almost all animal and vegetable substances are found to emit light in certain stages of putrefaction or

decomposition, and therefore it may be presumed to have been previously combined with some of their parts ; but how it acts, or whether it acts at all immediately in producing the colours of any object, seems yet uncertain, though we know it does contribute greatly to the production or change of colours in a number of animal and other substances, in some cases by combining with the basis of vital air (oxygen) and separating, by rendering it elastic, and in others, by promoting the action or union thereof upon or with particular substances ; but it seems difficult to ascertain the particular affinities, by which sometimes the one, and sometimes the other of these effects are produced. Thus, a solution of silver in the nitric acid changes colour by the action of light, and becomes black, which arises from the separation of a certain portion of oxygen ; the same is effected by the application of all inflammable bodies, and in this manner negro children which are white, immediately after birth become black, after having been exposed to the light a few days. With respect to those instances of the *nercis lacustris*, of the larvæ of insects, and of the tree frog, it does not appear certain to Dr. Bancroft whether the light produces the changes of colour by causing an abstraction or an addition of oxygen, but from what is known of its effects in cases apparently similar, he thinks it acts in one or other of those ways.

He thinks it does not appear reasonable to conclude, that light contributes to these effects on the colours of animal as well as of other bodies, otherwise than by its affinity with oxygen, which affinity under some circumstances, and with the aid of perhaps other unknown affinities, sometimes separates and renders the oxygen elastic by uniting with it, and at other times occasions the combination of an increased portion thereof, with the coloured substance. He thinks that Berthollet in his theory



has gone further than is warrantable by facts. He thinks the colour of each particular substance evidently depends on it's peculiar constitution, producing in it a particular affinity or attraction for certain rays of light, and a disposition to transmit or reflect certain other rays; and in this respect that it may doubtless suffer very considerable changes from the action or combination of oxygen, without any effects similar to those of combustion.

The opinion of Davy nearly resembles that of Dr. Davy. Bancroft. He states, that the cuticle, which is of the same colour, and equally pellucid in the different species of mankind, appears to contain no oxygen or light. and that it is most probably composed of carbon, hydrogen and nitrogen; that the rete mucosum is probably composed of carbon, oxygen, hydrogen and nitrogen; that the comparative quantities of carbon and oxygen in it appear to occasion the differences of it's colours, that these quantities depend on the quantity of oxygen attracted from it by light; thus light acting upon the rete mucosum of the African is continually subtracting oxygen, the principle to which it's whiteness is owing, and when the oxygen is subtracted, the carbon becomes the predominant principle; hence the blackness of the negro, and the less the inhabitants of a country are exposed to light, the more oxygen their rete mucosum will contain, and the more whiteness; hence the fair people of the north contain in their rete mucosum it's full proportion of oxygen. It appears that a subtraction of oxygen from the rete mucosum, by any means, uniformly blackens it; thus the application of sulphure of potash, according to Davy's experiments, blackens the skin almost instantly. On the contrary, by combining with oxygen the rete mucosum is uniformly whitened, thus Dr. Beddoes whitened the fingers of a negro by means of muriatic phosoxyd (from  $\tau\omega\varsigma$  light, and  $\sigma\acute{\epsilon}\nu\varsigma$  acid). which appears capable of



giving out a small portion of oxygen, and of still retaining all the light entering into its composition. According to this author, the different colours of the different parts of the organic matter of the body depend chiefly on the light and oxygen entering into their composition. Thus the red muscles are phosphydated compounds, which probably owe their colour to their light, whilst from the white colour of the nerves, and their office of conducting and being excited into sensible action by condensed light, we may conclude, that no light enters their composition.

To conclude, Davy is of opinion, that though the differences of the colour of the skin of different nations must have originally depended entirely on the chemical influence of light, yet when once these colours are produced, their changes are in some measure dependant on the mind; that when certain colours are considered as beautiful, the generating imagination makes them hereditary, and the chemical changes of the influence of light are more slowly produced; hence Europeans, though exposed to light in the African countries, do not become black but in a great length of time, and negroes, though deprived of light, their accustomed oxygen attractor, are not blanched for many generations.

Of light  
emitted by  
living ani-  
mals, or  
their dead  
parts.

Since light is found to have such an influence on animals and their parts, and that it appears to be imbibed by them, it may be supposed, that on certain occasions an emission of that luminous body must be the consequence, and this had not only been long ago observed with respect to living animals, such as some kinds of insects and worms, but even common flesh had been observed to display that appearance, as is evident from the accounts of Boyle, Fabricius ab Aquapendente, Bartolin, Dr. Beale, &c. but for a more minute and detailed investigation of this subject, we are indebted to Spallanzani,

Carradori, Brugnatelli and Dr. Hulme; the last, in particular, has greatly extended our knowledge of the properties of this luminous matter by a number of curious and interesting experiments.

These philosophers, as well as others, however, differ with respect to the origin of this light, which is emitted not only from living animals, but also from parts of them when dead; on one part, it is said, that it is nothing but phosphorus which is undergoing a slow combustion; on the other, it is asserted, that the rays of light being absorbed, are concentrated, and afterwards emitted according to circumstances. Perhaps, it is impossible at present to determine which of these opinions is the truth, a further investigation being necessary before a satisfactory division can be made.

Foster of Gottingen has observed, that the phosphoric part of the glow-worm is liquid, and if this animal be pressed between the fingers, the phosphorescence remains on them. Chaptal supposes, that as phosphorus is soluble in oils, particularly in volatile ones, which are then luminous, this combination of phosphorus and oil is natural in the glow-worm (*Lampyris splendidula*). According to Carradori, the phosphoric part of the Italian glow-worm (*Lampyris Italica*) does not extend further than the last rings of the belly; it is there enclosed in an envelop or bag, composed of a membrane, one portion of which forms the superior, the other the inferior part of the belly, and which are united together. Behind this receptacle the phosphorus is found, resembling a paste, having the odour of garlic, and only a little flavour: the phosphoric matter is squeezed out on the least pressure, but when separated from the body, it loses its splendour in a very short time, and is converted into a white, dry matter.

Spallanzani has made some experiments to determine the difference between the light emitted from phosphorus

Opinions of  
it's origin.

Light of  
glowworms.

Examined  
by Spallanzani.

and that of glow-worms, &c. He made them in opposition to those of Goettling, and with his eudiometer, which is the same as that described for the combustion of phosphorus, in the *Encyclop. Dict.* It consists of a glass tube, the lower end of which is open, and plunged into water or mercury. The upper part is closed, and bent horizontally, the phosphorus, or other shining matter, is put into that part about to be exposed to the action of the gas in the tube, and the diminution of the volume of this gas shows the quantity that unites with the phosphoric matter.

He first tried the action of different gases upon phosphorus itself, in their pure state, and found, that azot carbonic acid, and hydrogen gases introduced singly, one after the other, into the eudiometer, excited no light from the phosphorus. In very pure oxygen gas it did not begin to burn and produce light, till at  $22^{\circ}$  of Reaumur. If the azot gas was mixed with it, light was produced at  $12^{\circ}$ , and by the mixture of hydrogen gas at  $5^{\circ}$ . Spallanzani, however, does not conclude it is from the gases that the light originates, for oxygen gas alone produces it, but a high temperature is necessary, on the contrary, the other gases when alone, cannot produce it at any temperature. Hence it is the oxygen gas that is the immediate cause of the combustion, and of the light; and he thinks it can only be said, that the other gases dispose the oxygen and phosphorus to a more ready combustion, and at a lower temperature. The more oxygen in the mixture, the more lively the light, and the more of the other gases, the less is the occasion for raising the temperature; hence the oxygen is the cause of the production of light, and the other gases only make up for that temperature.

Having thus examined phosphorus, he directed his attention to what he calls other phosphoric substances, such as glow-worms, putrid fish, shining wood, &c. and these

presented to him the same phenomena as common phosphorus, as to the light. He found, that plunged into hydrogen or azot gases, they lose, by degrees, their phosphorescence, and sooner in carbonic acid gas, than they shine again on admitting common air, and become brilliant in oxygen gas. Water does not deprive them of their phosphorescence. The same was observed after their death, and in the luminous parts separated from their bodies.

He found the light of glow-worms to be strengthened by shaking, by the will of the animal, and this momentaneous increase of light was accompanied by a vibrating motion in the phosphoric part of the animal; it appeared to him to be made at the moment of breathing, and may be produced by pricking the animal. Exposed to a refrigerating mixture, the glow worm loses its phosphorescence at  $7^{\circ}$  and becomes hard from cold, but withdrawn and placed in a mild temperature, it becomes luminous again. It also loses its light on exsiccation, and receives it again on being softened with water. Spallanzani concludes, that the light of these phosphoric bodies arises from a slow combustion of the hydrogen and the carbonated hydrogen gases, of which animal and vegetable substances are in part composed.

Fourcroy explains the origin of the light of phosphorescent bodies, from the disengagement of the real phosphorus itself dissolved in the hydrogen and carbonic acid gases. Fourcroy.

Although it is the opinion of Spallanzani and others, of combustion being the cause of light in the phosphorescent bodies, there are several celebrated chemists who entertain a different opinion, and that light is only extricated.

Brugnatelli calls that light which bodies have the power of absorbing, during their exposition to the rays of the sun, Brugnatelli.



*aggregate sensible light.* He affirms, that the eyes of the hyena and cat possess this power even to the point of enlightening objects, and in short, all animals called phosphoric shine from the disengagement of the aggregate light. He, however, observes, that those bodies which emit light, or become phosphorescent on being heated to a certain degree, for instance, as feathers, wool well dried powder of sugar of milk, fat and sweat, &c. when lightly passed upon a hot iron that is not red, disengage their light *by combining with caloric*; hence light chemically combined only separates from these from the effect of *a greater attraction*.

Carradori.

But of all the opponents to the doctrine of phosphorescent light being produced by combustion, perhaps Carradori may be looked upon as the most formidable. His observations are particularly directed against those of Spallanzani.

Carradori found, that the phosphorescent light of glow-worms (*lucioloni & lucciole*) is suddenly extinguished if plunged into alcohol or vinegar, but continues to shine under oil, as well as in water or air; he has seen the glow-worms as well as the phosphorescent part detached from them, continue to shine under oil for hours together. If therefore these two kinds of glow-worms, which are of different species, and likewise phosphoric wood, continue to shine under oil, the light cannot proceed from a slow combustion, as Spallanzani pretends, since there is no air in oil to entertain it; and if the glow-worm shines under water, because, as Spallanzani maintains, the oxygen gas, which is one of the principles of the water, swells the combustion, why, he asks, does not the phosphorus of Kunckel shine under water? Carradori has likewise seen a glow-worm that continued to shine perfectly in vacuo. He affirms, that the light of these insects is peculiar and innate, and as several other animals have the power of



accumulating the electric fluid, and of keeping it condensed in peculiar organs, to emit and expand it afterward at will, so may the glow worms have the faculty of retaining, in a state of condensation, the fluid which constitutes light; he thinks that they may have the power even of extracting the light which enters into the composition of their aliments, and of transmitting it into the reservoir in their abdomen; or it is possible they may have the power of extracting the luminous fluid from the air, as other animals do heat from it by a chemical process; and the new doctrine of Goettling on combined light, which has been simplified by Brugnatelli, renders this opinion, he thinks, very probable.

He is of opinion, that the observations made by Forster, that glow-worms emit a stronger and more lively light in oxygen gas, than in common air, does not depend on combustion, and it's being rapidly excited by the respiration of this gas, but arises from a more agreeable and lively existence they feel, for the same happens in other circumstances. Thus when they fly freely without any interruption, their light is regular and beautiful; but once in our power, they either emit light irregularly or not at all. On being disturbed, they emit a frequent light, and this appears to be a mark of resentment; when placed upon their backs, they shine almost without interruption, by making continual efforts to extricate themselves. During the day, they must be tormented to shine, a proof of it's being the time of their repose. They can shine at will in every point of their belly, a proof of their being able to move any part of it independent of the other, and they render this phosphorescence more or less lively, and emit it as long as they please. On being plunged into warm and cold water, alternately, they shine with vivacity in the first, and extinguish their light in the last, another proof of an alternately agreeable and disagreeable

sensation, giving rise to or diminishing it; in hot water, the light disappears by degrees. Hence their light does not depend on external causes, but on their will. He likewise found, that from his experiments on them, the phosphoric matter undergoes no soluble action except from water.

This faculty of shining is not destroyed, according to Carradori, by incision, or tearing open the belly; he saw a part of one, almost extinguished, become suddenly luminous for a few seconds, and then insensibly go out; and sometimes he has seen a similar portion cut out, pass suddenly from the most beautiful brilliancy to a total extinction, and reassume in a moment its pristine brightness. He attributes this to a remnant of irritability, or more probably to the stimulus of the air, a mechanical irritation producing the same. A slight compression takes away their faculty of ceasing to shine. A piece of the phosphoric belly put into oil shone but faintly, and was soon extinguished. Exsiccation he found to suspend the light, whilst softening in water made it reappear again. Reaumur, Beccari, and Spallanzani, observed the same with respect to the medusa, &c.

Carradori, therefore, differs from Spallanzani, who looks upon the cause of phosphorescence to be a slow combustion; and from Goettling, who attributes it to the fixation of the azot gas; and concludes, that it arises from a dissipation of aggregate light. He supports this against the philosopher of Pavia, upon the experiments of Beckerheim, who has demonstrated that phosphoric insects shine when plunged in gases improper for combustion; and upon those of Beccari, Brugnatelli, and Dufay, who have proved that light may combine and accumulate in bodies, in a greater or less quantity, according to their capacity for it.

Dr. Hulme's  
experiments  
on light  
&c. &c.

Dr. Hulme distinguishes this light emitted by various bodies from all kinds of artificial phosphori, by calling it

*spontaneous light*; and by it's adhering to bodies with some degree of permanency, from that transient sort of light observed in electricity, in meteors, and in other lucid emanations.

The substances from which it is emitted are principally living and dead marine animals; of the first, are the shell-fish, called pholæ, the medusa phosphorea, and other molluscæ; of the second, marine fishes in general, when dead, abound with it. In the class of insects, it is well known, many emit light very copiously, particularly several species of fulgora or lantern fly, of lampyris, or glow-worm, as observed before; also the scolopendra electrica, and the cancer fulgens.

Boyle obtained light for his use from the whiting; but Dr. Hume procured it for his experiments, chiefly from the herring and mackerel. His laboratory was a dark wine vault, the heat of which varied throughout the year from about  $40^{\circ}$  to  $64^{\circ}$  of Fahrenheit. The weight he used was troy; the liquid measure, wine; and the water, pure spring, and always cold, except otherwise expressed.

1st. From the experiments of this physician on herrings and mackerel, which he had previously gutted, scaled and hung in his laboratory; it appears that light begins to be emitted by them before any signs of putrefaction appear, and that as soon as a great degree of putrescence has taken place, the luminous property of marine fishes is destroyed and the light extinguished; which corroborates the observations of preceding authors on the luminous appearance of the flesh of quadrupeds, all of whom say it was fresh; whenever, therefore, Dr. Hulme was desirous of obtaining a plentiful supply of light from these marine animals for his experiments, he always procured the fattest he was able. This proves that the common opinion, of the quantity of light emitted by animal substances being in proportion to the degree of putrefaction,

is erroneous, and that on the contrary, the greater the putrescence, the less is the quantity of light emitted.

2. He found that this light is a constituent principle of these bodies, that it may be separated from them by a peculiar process, and retained and rendered permanent for some time, for it seems to be incorporated with their whole substance, and to form a part of them in the same manner as their other constituent principles.

He put pieces of fresh herring, weighing about four drachms each, in aqueous solutions of different quantities of Epsom and sea salts, and in sea water; the phial which contained them having a wide mouth, and he found, on the second or third night, they became luminous, which light gradually disappeared on the sixth or seventh. Similar experiments were also made with the roe of herrings, the flesh and roe of mackerel, and with the tadpole, the flesh and roe remaining quite fresh and sweet, which proves that the menstruum had extracted their light. The soft roe abounds more with light than the flesh, whilst the hard roe is less luminous than the soft; he found the most luminous state of the soft roe to be about the third or fourth night, when it sometimes shone so very splendidly as to appear like a complete body of light: they were laid upon plates in the laboratory. Dr. Hulme, therefore, concludes, that this light forms one of their constituent principles, that it is separated by the menstruum employed, in the same way as the principles of any other body are separated by the menstruum fitted to decompose it; and as the light appears in the internal part on exposure after being cut, he thinks it shows, that it is not partial, but wholly incorporated with every part of their substance, forming a part thereof, like any other constituent principle. Hence it seems probable, that light is the first constituent principle that escapes after the death of marine fishes, as it appears soon after,



and the flesh and roes infused in the saline menstrooms continued to emit light for several days without undergoing any apparent putrefactive change. His experiments also render it probable, that no offensive putrefaction takes place in the sea after the death of such myriads of animals as daily perish in the vast ocean, which is quite contrary to what happens on land, and that the flesh of marine animals remains pretty sweet for some time.

3. Dr. Hulme found, that some bodies have a power of extinguishing this spontaneous light when it is applied to them; for the luminous matter of the herring and mackerel was quickly extinguished when mixed with,  
 1. Water alone; 2. Water impregnated with quicklime, carbonic acid, and hepatic gases; 3. Fermented liquors, ardent spirits; 4. Vegetable acids and mineral, both concentrated and diluted; 5. Fixed and volatile alkalis dissolved in water; 6. Neutral salts, viz. *saturated* solutions of Epsom and common salt, and sal ammoniac; 7. Infusion of chamomile flowers, long pepper, and camphor, made with boiling water, but not used till quite cool; 8. Pure honey, alone.

4. He found, that other substances have the power of preserving spontaneous light some time, when it is applied to them, for some of the luminous matter scraped from the herring, and mixed with a solution of two drachms of Epsom salt in two ounces of cold pump water, being well shaken in the phial, the whole liquid became richly impregnated with light, and continued shining for above 24 hours. The same took place in a solution of Glauber's salt. Mackerel-light afforded the same phenomenon in the aqueous solutions of Rochelle salt, or tartarized natron, common salt, sea water, aqueous solution of honey; and herring-light in the solutions of soda phosphorata, saltpetre, refined sugar, and soft brown sugar; the degree of illumination depending on the quantity of lucific mat-



ter applied; in general, however, as much as can be scraped off by the blunt point of a moderate sized knife, at a few times, will be sufficient when assisted by a strong agitation of the phial. By such means the whole liquid is rendered most brilliantly luminous; and we are enabled to impregnate the water with light, which light is so extended on it's surface, and combined in such a manner, as to become exceedingly convenient and useful for various other experiments.

5. He found, that when spontaneous light is extinguished by some bodies, it is not lost, but may be again revived in it's former splendour. Some shining matter from the mackerel was immediately extinguished in a solution of seven drachms of Epsom salt in one ounce of water; but in a solution of two drachms it was luminous, and more so in one drachm; observing, therefore, the extinction of it in the more saturated solutions, while the diluted were luminous, he endeavoured to find what became of the extinguished light, and whether it might not be revived by dilution, and found, that on diluting the solution of seven drachms with six ounces of water, light immediately burst out of darkness, and the whole liquid became beautifully luminous, which remained above 48 hours, *i. e.* as long as other light does in general, which has never been extinguished; and by reversing the experiment, extinction is the consequence. In one instance the same light, by a repetition, underwent ten extinctions.

Dr. Hume found, that if the illuminated liquid be uncommonly brilliant, it may sometimes require more salt to extinguish the light than what he has specified, in which case, the measure of water for dilution must be always calculated in exact proportion to the weight of the salt employed.

6. Spontaneous light is rendered more vivid by motion, for some illuminated liquor which had become

quite dark, on drawing through it a finger or rod, it was followed by a luminous line, and on moving another quantity gently, that had lost it's luminous quality, except a little glimmer floating at the top, the light diffused itself gradually through the whole liquid; on agitation, the lucidness was much increased, and the brisker the motion, the more vivid was the illumination.

7. Spontaneous light is not accompanied with any degree of sensible heat to be discovered by the thermometer, for a luminous and a nonluminous herring being in the same temperature, afforded no difference to the thermometer, the bulb of which was applied to them, nor did the mercury rise when it was placed either upon a luminous soft roe, or upon a lucid mackerel.

8. Dr. Hulme tried the effect of cold on this spontaneous light. He placed gallipots containing pieces of soft roe of herring, and of herring itself, all luminous, in a frigorific mixture of snow and sea salt, and the light was extinguished in half an hour, and the bodies frozen. On removing the gallipots into a vessel of cold water, they recovered their former luminous state as they thawed, and shined for three succeeding nights. The same took place with some liquid impregnated with light, and placed in a cold mixture. The light of the glowworm was affected in the same manner; hence cold extinguishes spontaneous light in a temporary way, but not durably, since a moderate temperature revives it again.

9. He tried the effects of heat on spontaneous light. One side of a luminous fish exposed to the fire so as to heat it strongly, was quite dark on that side in the laboratory, whilst the other remained luminous; and the light did not reappear. A whole herring, very splendid, being thrown into boiling water, had it's light immediately extinguished, nor did it afterwards revive. Dead shining glowworms being put into a phial of water at  $58^{\circ}$ , and sunk in

boiling water, their light became more vivid; the glowing property was also augmented at  $114^{\circ}$ . Heat also, obtained from solid bodies by friction, increased it; thus two living glowworms perfectly dark, put into a phial that was rubbed briskly till it became pretty warm, generally displayed a fine light. The same took place on the light of a dead glowworm.

On pouring some boiling water on a dead luminous glowworm, it was immediately extinguished, and did not revive. Dr. Hulme found, that any of the saline solutions mentioned at 4, on being impregnated with light and left some time at rest, were rendered more lucid by a *moderate* degree of heat; but their light was extinguished by a *great* degree of heat. It appears that this species of light, united with water, begins to be extinguished at from  $96^{\circ}$  to  $100^{\circ}$ , and that the method of adding the hot water by degrees, and in small quantities, is very elegant, and shows how much heat is requisite to extinguish the light; but to prevent the possibility of any light being renewed after an experiment of this kind, requires a much greater heat than that of  $100^{\circ}$ .

Dr. Hulme found that if much heat be applied to the bottom of a tube filled with illuminated liquid that has been some time at rest, the light will descend in luminous streams from the top of the tube to the bottom, and be gradually extinguished. He filled a tube nine inches long, and  $1\frac{1}{8}$  of an inch diameter, which was closed at one end, with some very luminous liquid over night; and procured a gallipot three inches and a half deep, and three and a half wide, holding 12 oz. of boiling water, the next evening; the tube which had been placed in the laboratory, and the light of which had ascended plentifully, taking the circular form of the tube, and forming a very lucid ring at the top of the fluid, had it's bottom immerged in the boiling water in the gallipot, when the light ap-

peared to descend in about the space of half a minute in streams to the bottom, illuminating the whole fluid during it's descent in a very beautiful manner, and then was gradually extinguished. This extinction began at the top and ended at the bottom. The most eligible solutions for this kind of experiment are made of Epsom and Glauber's salts, sea water and sal ammoniac; and the experimentalist, before he views the descent of the light in the tube, should always remain in the dark for some little time, to get rid of all the extraneous light adhering to the organs of vision, and to accustom the eye to darkness.

10. The effects of the human body and of the animal fluids upon spontaneous light, Dr. Hulme found to be as follows: 1. *The living body*. On touching the luminous part of fishes, the light adhered to the fingers and different parts of the hands; it remained very lucid some time and then gradually disappeared; but on being applied to pieces of wood, stone, &c. of the same temperature as the laboratory, it continued luminous upon them for many hours. 2. *Blood*. Herring light mixed with crassamentum or red coagulated part of the blood, and well stirred, became slightly luminous, but not of long duration; nearly the same happened on mixing the lucid matter with recent crassamentum of pleuritic and rheumatic people; but with black and offensive crassamentum the light seemed to be more quickly extinguished. There was a curious circumstance, that on mixing fish light with putrescent bloody serum, it would not incorporate, but was ejected in globules like quicksilver, and afterward adhered to the side in form of a lucid ring. Mixed with pure healthy serum, the herring light was soon highly illuminated. 3. *Urine*. Mackerel light being strongly agitated with fresh urine, a glimpse of light was retained at first, and then gradually extinguished; but stale and

pungent urine had a still more extinguishing effect. 5. *Milk.* Mackerel light incorporated by strong agitation with fresh cows milk, became highly luminous and continued shining above 24 hours. Fresh cream also retained some light, though (perhaps owing to it's thickness) it was not so visible as with milk. When, however, milk or cream turns sour, it contracts a very extinguishing property, as it puts it out immediately.

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## COLOURING MATTER.

Colouring  
matter.

It appears, on treating of the action of light on animals, that it has a great influence on the production of their colours, and that light itself when imbibed by bodies, may become the subject of curious inquiries; it now remains to give some account of the nature of colouring matter, and of the chemical action which different reagents have upon it, for the purposes of dying. Upon taking a general view of the animal creation, we find there is a great variety of colours, not only in different animals, but even in the parts of the same animal. Thus, in man, and all quadrupeds in particular, blood is from a bright vermilion colour to a dark purple; in insects it is white; the flesh of the former is universally red; that of fish generally of a more or less pale colour. The nerves of an animal are of an opaque pearl, whilst the tendons shine like silver, and the brain, the liver and the lungs have each their peculiar colour; the same may be said of the other parts. In some animals, likewise, it appears that colours only pervade the surface and cannot be collected, or if they are, the colouring tinge is slight and evanescent, and soon dissipates; in other animals, or their parts, the colour is as it were so concentrated as not only to be ca-



pable of being extracted by different menstua, but so stable as to be communicated to other substances to which a colour is given equally firm and durable. This matter, the colour of which can be so communicated, may be called the *colouring matter* of animals, and it is from this kingdom that the most rich and exquisitely beautiful colours are to be extracted, although they are very few in number.

With respect to the origin of colour, little or nothing is known. According to the principles of optics, the colouring parts of an animal (as well as of the other kingdoms) may be said to be those parts which possess or acquire a power of acting on the rays of light, so as either to absorb them all, and produce the sensation of black, as the ink of the cuttle fish, or, only to absorb particular rays and transmit or reflect the others, and thereby produce the perception of that particular colour which belongs to the ray so transmitted or reflected.

Some have attributed the power of acting on the rays of light to phlogiston, others to the presence of iron, but the candid and impartial judge must acknowledge the want of a satisfactory explanation.

There is great reason to believe that it depends upon the proportion of the component parts of bodies, more than upon the particular form or shade of those ultimate parts; and the prevailing opinion is that the most essential circumstance in the production of colour depends on the absence or the different quantity of oxygen, which the coloured matter retains in it's composition. A comparative view with the different oxyds of the metals, the colours of which appear to depend on the different proportion of oxygen they contain, may afford strong arguments in it's favour; but in animal substances, as the oxygen cannot easily be separated without decomposing the other component parts, it is much more difficult to determine whether the colours depend upon the different pro-

portions of component parts, and in what manner they are affected by the absence or presence of the oxygen. A further investigation is necessary to clear away all the doubts on this interesting subject. In the mean time we must rest satisfied with the explanations of the three ingenious chemists before mentioned.

Experi-  
ments of  
Delaval.

Independent, however, of the form and figure of the particles of bodies, the opinion of sir Isaac Newton (who asserted that *all coloured matter reflects the rays of light*, some bodies *reflecting* the more refrangible, others the less refrangible rays, more copiously, and which he affirmed was the only true reason of these colours) has been called in question, and in the progress of inquiry another theory has been attempted, which Delaval supports by numerous experiments. They were first made on transparent coloured substances, as being of the simplest kind, consisting only of the colouring particles united with and diffused throughout transparent media, such as spirit of wine, water, &c. From the examination of such tinged media he has been enabled to discover several properties of coloured matter, very different from what has hitherto been supposed to prevail: for instance, Delaval affirms, from his experiments, that in transparent coloured substances, *the colouring matter does not reflect any light*, and when by intercepting the light which is transmitted, it is prevented from passing through such substances, they do not vary from their former colour to any other colour, but become entirely *black*.

For the purpose of observing the manner in which transparent coloured bodies act upon the rays of light, he procured small vials of flint-glass, of a parallelopiped form. He covered the bottom and three of the sides of each of these phials with a black varnish, the cylindrical neck and the anterior side, except at its edges, were left uncovered; hence no light could be admitted, except through

the neck and anterior side of them. The uncovered side should be placed opposite the window, but in such a direction as to form a right angle with it. He constantly found that the liquor in the neck exhibited it's colour distinctly and vividly, whilst that in the body of the vials, viewed through the uncovered side, exhibited no colour, but was black; and as to the expressions *reflected light* and *transmitted light*, as transparent coloured bodies are not endued with any *reflective* power, the word *reflected* cannot be properly applied to the light which falls on them; he has therefore substituted the words *incident light*, instead of *reflected light*.

TABLE of transparent coloured liquors viewed by transmitted and by incident light, from the animal kingdom.

	By transmit- ted light.	By inci- dent light.
1. Cochineal infused in distilled water	red.	black.
2. ————— in spirit of wine	red.	black.
3. Kermes infused in distilled water	yellow.	black.
4. ————— in spirit of wine	yellow.	black.
5. Ox gall diluted with distilled water	yellow.	black.
6. Blood with spirit of sal ammoniac	red.	black.

The few experiments just cited are those which Delaval made on animal substances, and are extracted from a numerous collection of others made in the three kingdoms. The author informs us, that these show, that transparent coloured liquors do not, as before asserted, yield any colour by reflection, but by transmission only. If these liquors are spread thin on any white ground, they appear of the same colours which they exhibited when viewed in the necks of the vials, as the light reflected from the white ground is, in this case, transmitted through

the coloured medium; but when they are spread upon a black ground, they afford no colour; but the black ground should not be a polished body, as the light reflected by it would be transmitted through this medium on it's surface, and be tinged by passing through it.

He found also that opaque bodies do not exhibit their colours by reflecting the rays of light: he affirms this to be a general law; and as animal substances do not afford any great variety of coloured products, yet, since in those which do exhibit colours, the colouring particles are endued with the same properties which prevail in vegetables, they must be regulated by the same laws. In vegetables, on depriving them of their colouring matter, there remained a solid white earthy substance, which is the only part of them endued with a reflective power; he asserts, their colours are produced by the light reflected from this white matter, and transmitted from it through the coloured coat or covering which is formed on it's surface by the colouring particles; and that when the colouring matter is discharged, the solid earthy substance is exposed to view, and displays that *whiteness* which is it's distinguishing character. In like manner flesh, which consists of fibrous vessels containing blood, is perfectly *white*, when divested of the blood by ablution. The membranes, sinews, bones, and other solids are white, and when freed from their aqueous and volatile parts, they are a mere white earth, unalterable by fire, and incapable of imparting to glass an opaque whiteness.

From the experiments with blood abovementioned in the vials, and from the above considerations, it appears to Delaval, that the florid colour of the flesh arises from the light which is *reflected* from the *white* fibrous substance, and transmitted back through the red transparent covering, which the blood forms on every part of it.

The blood whilst recently drawn does not assume the

appearance common to transparent coloured liquors, for such liquors, when too massy to transmit light from their farther surfaces, are black. But blood recently drawn yields a red colour, in whatever masses it is disposed. The colour thus exhibited arises from a white matter diffused throughout the blood. This white matter is easily separable from the red part of the cruor. This may be performed by dividing the cruor after it is coagulated into thin pieces, upon which a sufficient quantity of water must be poured. The cruor communicates a red tinge to the water, which should be changed every day; after a few days, the water no longer receives any tinge, and the remaining masses of the cruor are by these means rendered perfectly white. Thus it appears, that not only the flesh, but also the blood itself, are white substances tinged with red particles.

The red colour which the shells of lobsters assume after they are boiled, is a mere superficial covering, spread over the white calcareous earth of which the shells are formed, and may be easily removed by scraping or filing the surface. Before this superficial covering is attenuated by the heat, it is much denser, so that in some parts of the shells it appears black, as it is too dense to admit the passage of the light to the white substance of the shell, and back again. But where this transparent blue colour is spread thinner and rarer, the light reflected from the white substance of the shell is transmitted back through the blue film, and yields a light blue colour. The colour of the shells of several species of eggs is also merely superficial, and may be scraped off, leaving the white earth of the shell exposed to view.

Feathers in like manner, according to Delaval, owe their colour to thin layers of coloured matter, covering the white substance, of which they are principally formed. He scraped off the superficial colour from such parts of



vividly coloured feathers as were solid enough to admit of that operation, and by this means separated the coloured layers from the white ground, on which they had been naturally spread. The surfaces of the lateral fibres of feathers cannot be thus separated on account of their minuteness. But as they appear, when viewed with a microscope, nearly to resemble in their form the feathers themselves, it seems probable, that their colours arise from a similar matter and conformation in the smaller fibres, as in the grosser parts of the feathers.

The colours of all animal substances, which have fallen under his observation, appear to him to be effected in the manner described. In all the instances, the colours of the bodies are produced by the light reflected from a white substance, and transmitted back from it through a transparent coloured covering. The colouring particles were extracted from such of the bodies as were capable of yielding them to any proper solvents, and in their state of solution, as well as when condensed into a solid consistence, they were constantly found to possess a power of transmitting colour, but to be devoid of any reflective power.

In the examination of some animal subjects, when the colouring matter could not be separated from the white substance by chemical means, he had recourse to mechanical methods of effecting their division. But such methods, he confesses, can only be employed when the principle part of the white substance is unmingled with the coloured coat or covering which is spread upon its surface.

To conclude, from all the experiments and observations of Delaval, it appears that all colouring matter, whether animal, vegetable or mineral, is transparent; that it does not reflect colours, but exhibits them by transmission only; and that opaque coloured bodies consist of transpa-

rent matter, which covers opaque white particles, and transmits the light that is reflected from them; and this white substance which composes animal and vegetable bodies consists principally of calcareous earth. All colouring matter is black when viewed by incident light, and all substances incline to blackness in proportion as they are copiously stored with tingeing particles.

Bergman appears to have been the first who observed that the colouring matter of bodies possesses chemical properties that distinguish it from all other matter; for besides its several affinities with particular rays of light, it has others which render it susceptible of being acted upon and modified by a variety of chemical agents, and of forming permanent combinations with other substances, such as the filaments of wool, silk, cotton, linen, &c.

This matter  
possesses  
chemical  
properties.

It is from these affinities that the art of dyeing arises, and those beautiful colours communicated that so much adorn the elegancies of taste; since, however, these affinities are of various strength, some being strong enough to form with the substance to be dyed a permanent colour, whilst others require an intermedium to unite them together, colouring matters have been divided into two kinds:

Two kinds  
of colouring  
matters.  
Substantive.

1. Those the attractions of which for the particles of the different stuffs are sufficiently strong of themselves for the colour to be fixed, have been called by Dr. Bancroft *substantive* colours.

2. Those of which the attractions are not sufficiently strong of themselves, but require some earthy, metallic, or other body that has an attraction for both, by which a bond of union is formed and the colour fixed, are called *Adjective* colours.

3. The body that is interposed is called the *mordant* or *Mordant-basis*.

Amongst the first may be reckoned the Tyrian purple; and amongst the second, the different red colours of the animal kingdom, for which we are indebted to the insect tribes. The *purple* is supposed to have been produced by a snail, a species of *murex*, and the *red* is taken from several species of the genus *coccus* of the order hemiptera of insects, such as the *coccus cacti*, *ilicis*, *lacca* and *polonicus*. According to Olivier, useful colours may likewise be obtained from the coleoptera order, particularly one from the *meloe proscarabæus*; and in America there is a large green worm which infests the tobacco plant; this when bruised affords a considerable quantity of a green liquor that might be useful as a dye. Thus whilst a few of the mammalia regale us with their excellent perfumes, these smaller tribes add their tribute to the arts of man, by presenting him with the most rich and brilliant of colours.

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#### TYRIAN PURPLE.

Tyrian purple.

It's discovery and great antiquity.

THE origin of the discovery of the famous purple so much boasted of by all antiquity is perhaps unknown. Tradition has handed down to us different accounts of it. It is related, that a shepherd's dog, being pressed with hunger, broke a shell upon the sea shore, when the blood that ran from it stained his mouth of so beautiful a colour as to strike the admiration of those that saw it; they endeavoured to make a dye of it, and succeeded. Another account is, that, at the time Hercules was in love with the nymph Tyros, his dog happening to find a shell on the sea shore, broke it, and his mouth was stained with the purple. The nymph observing it, and charmed with the richness and beauty of the colour, declared to her

lover, she would see him no more until he brought her a garment dyed with the purple. Hercules succeeded by collecting a number of shells, and brought the purple robe she had demanded.

Some place this discovery in the reign of Phœnix second king of Tyre, about 500 years before Christ; others at the time that Minos the first reigned in Crete, about 1439 years before the christian æra. The greater number of authors, however, give the honour of the invention of dying stuffs purple to the Tyrian Hercules. He gave his first trials to the king of Phœnicia, and that prince became so jealous of it's beauty, that he forbade it's use to all but his descendants and the presumptive heir of the crown. With respect to the explication of the fable of the discovery, we are informed by Bochart, that in the Syriac language the same word signifies *a dog* and *a dyer*, which the Greeks applied to the former animal. The antiquity however of the discovery, as observed by Gouguet, is confirmed by the testimony of Homer, who gives purple ornaments to heroes who lived about the age in which it is said to have been made known.

The purple dye was drawn from many kinds of sea-shells, but the best were found near the isle where new Tyre was built. They likewise fished for them in other places on the Mediterranean. The coasts of Africa were famous for the purple of Getulia, and the coasts of Europe supplied the purple of Laconia, which they held in great esteem.

According to the accounts of Aristotle and Pliny, to whom posterity is indebted for almost the only account, it was obtained from an univalve shell fish. Pliny, in whose time it seems this dye had attained it's greatest perfection, divides the principal shell fish which afforded it into two species; the first, comprehending the small species, he called buccinum or whelk; the second included

Whence  
extracted.

Account of  
Aristotle  
and Pliny.

those called purpura, and were of a larger size. Both species were subdivided into several varieties; they were likewise distinguished by the more or less beautiful colour they gave, and according to the coasts where the fishery was carried on. These are supposed by Fabius Columna to have been also distinguished by the generic name of murex. The juice was contained in a small vein found in the body of the buccinum quite colourless; it likewise, when broken, contained a very small quantity of a red liquor shaded with a black tinge, the *nigricans rosa* of Pliny. The colouring juice of the purpura was found in a vessel in the throat, but so small was it in quantity that only one drop could be extracted from each animal.

It's preparation.

When a sufficient quantity of the colouring juice was extracted, a certain portion of marine salt was added to it; it was then macerated for three days, after which five times the quantity of water was added, the mixture kept in a moderate heat, and the animal parts which rose to the surface were separated from time to time. These operations lasted ten days, after which the liquor was tried whether it had taken the proper degree of colour by means of a piece of white wool.

Methods of dyeing with it.

Previous to the dyeing, the stuff was differently prepared; some dipped it in lime-water, others made use of a species of fucus which acted as a mordant to render the colour more fixed. We are informed, that the liquor of the buccinum did not afford a fixed colour of itself, but it increased the brightness of the colour of the purpura. In dyeing the Tyrian purple, they began with the juice of the purpura, then a second dye was given with that of the buccinum; hence Pliny gives it the name of *purpura dibatha*. In other processes, the juices of the two were mixed; for instance to dye 50lb. of wool, 200lb. of the buccinum, and 100lb. of the juice



of the purpura were taken, by which means an amethyst colour was obtained; sometimes a *ground* was given with the coccus (the modern kermes), and afterwards the juice of the purpura was used. Likewise a great variety of purples were obtained by uniting some of these methods, which were distinguished by different names; thus, according to Pliny, that of Tyre was of the colour of coagulated blood, the amethyst purple took its name from the stone, another species resembled violet, &c. It appears that some kinds of purple preserved their colour a long time, for it is related by Plutarch in the life of Alexander, that the Greeks found a great quantity of purple in the treasury of the king of Persia, the beauty of which had not changed during 190 years.

The very small quantity of juice extracted from these animals, and the length of the operation of dyeing, made the purple of so high a price, that at the time of Augustus one pound of wool dyed with the Tyrian purple could not be bought for thirty pounds. It is supposed from the commerce of this precious dye, that it contributed much to the opulence of that once celebrated city. From its great price it was, as may be supposed, an attribute every where of high birth and dignities, the purple therefore decorated the first magistrates of Rome; but as it soon became less scarce amongst the opulent, it was at last reserved, under pain of death, to the emperors; whilst the priests, every where busy, canonized it as a colour agreeable to the divinity, and which when first known was arrogated by them for his worship. It's dear-  
ness.

For many centuries nothing was known respecting the two juices which formed the Tyrian dye, except what the ancients had left us; so that although Aristotle and Pliny had given some intimations of their being primitively white, and Pliny had mentioned one of the intermediate colours or green which takes place, yet the other Rediscovered  
by the  
moderns.

colours they undergo on exposure to the rays of the sun were not distinctly noticed, until the animals which afford them were discovered at the end of the last century and the beginning of the present. It was not till then that any adequate conceptions could be formed of the changes they underwent before they became purple.

Cole and  
Reaumur  
discover  
the bucci-  
num.

For the identity of the shell fish of the ancients with those of the moderns, we are indebted to Duhamel, who discovered the purpura, and to Cole and Reaumur who found the buccinum.

The bucci-  
num.

With respect to the buccinum, it was found in 1686 by Cole in great plenty on some of the Irish shores, on the shores of Somersetshire, and the opposite ones of South Wales, and considerable profit was made of it by marking linen with it's juice of a fine durable crimson colour. A small species of the buccinum was likewise found by Jussieu on that part of the French coasts which is washed by the Atlantic; it resembled in form the garden snail, and was presented to the Royal Academy at Paris in 1709, whilst in the following year Reaumur found great quantities on the coast of Poitou. The shell of the buccinum, which is considerably hard, is first broken by a small blow, taking care not to crush the body of the fish within. After picking off the broken pieces, Cole found the juice in a little white vein or reservoir, lying transversely in a small furrow or cleft near to the head of the fish; this white liquor being taken out is clammy, and if characters be drawn with it, or if it's viscid juice be squeezed upon linen or silk, the part acquires immediately on being exposed to the sun, a pale yellowish green, which quickly deepens into an emerald green, then changes to a blue, and lastly to a deep purple red. This succession comes on so quickly as scarcely to be distinguished, and the changes are made quicker or slower, according to the degree of the sun's heat. If the cloth be now washed with scald-

ing water and soap, and laid again in the rays of the sun, the colour changes to a beautiful crimson; which suffers no further alteration from sun or air, or any of the substances used for assaying the permanency of colours. Cole likewise found, that whilst linen marked with this white liquor was drying by exposure to the sun during the first time, it always yielded a very strong fetid smell resembling a mixture of garlick and *assa foetida*; it appears also that the purple of the ancients had a strong smell.

With respect to the purpura, we are informed by du Hamel that it's juice receives no colour, nor communicates any, either to silk or linen, without exposure to the sun; that it is the light and not the heat of it's rays that calls it's colour forth; for when the silk or linen is covered with thin opake bodies which transmit heat without light, no colour is produced, whilst transparent bodies do not impede it. Likewise the light of a culinary fire concentrated by convex glasses and concave mirrors has no effect upon it. Du Hamel, who found the viscid colouring liquor of this fish white, except in a few instances where it was green, and which he supposed originated from disease, gives the colours it assumed on exposure to the sun in the following order. 1st. A pale green or yellow. 2d. an emerald green. 3d. a dark bluish green. 4th. a blue with an incipient redness. 5th. a purple. These colours took place in less than five minutes, and it only became green when not exposed to the light. According to Lewis, this succession of colours is best observed when the sun is low and his action is weak, whilst at noon in summer they are so quick as not to be easily distinguished. Du Hamel found it in great abundance on the coasts of Provence. Snails possessing the same property are found to exist in various parts of the world. From the account of John Nieuhoff, there are an abun-

Du Hamel  
discovers  
the pur-  
pura.

Others pos-  
sessing the  
purple co-  
lour.

dance of purple snails found in the islands over against Batavia, and it appears that the Chinese have the custom of eating them, at the same time they pick out of the middle of the animal a purple coloured substance which they use as red ink. According to Dr. Peyssonnel a naked snail, producing a purple colour, is found in the seas of the Antilles; and is looked upon as precious for the beautiful purple colour it produces, which is purple without the aid of light. It is emitted in the same manner as the black ink of the cuttle fish or sepia, which when in danger surround itself with it's viscid bitter black fluid; this last was used as ink by the Romans, and is said at this time to form the basis of the Chinese or Indian ink.

In the history of Jamaica by Dr. Brown, is a description of two shell fish containing a similar purple colouring liquor. The one is termed the *larger dark lernca* or *sea snail*, and is very frequent in the American seas. On touching this animal, he observes, it emits a considerable quantity of a viscid purple liquor, which thickens, and colours the water so much, that it is scarcely to be seen for some time, by which means, like the cuttle fish, it escapes danger. This liquor colours linen of a beautiful dark purple, not apt to be changed either by acids or alkalis, but it differs from that of the buccinum by being readily washed out, as well as being naturally emitted of a purple colour. The other of these shell fish is called the *purple ocean shell*, and on being touched it emits a liquor resembling the former.

To these it may be added on the authority of Reaumur, that on some of the French coasts he found great numbers of small elliptical spheroidal bodies adhering to the rocks by a short stem like fruits, and that the purple fish were commonly accumulated plentifully about these. On examination of the bodies he found them to be visi-



cles filled with a liquor of the same quality as the juice of the fish, but less viscid and more readily spreading upon linen. At first he suspected them to be eggs, perhaps of the purple fish, but could not observe any thing like them on dissection. They are only in perfection in autumn, whilst in summer they have either lost their colouring juice, or the juice it's power of becoming purple in the sun. And Gage relates that some shell fish were found near Nicoya, a small Spanish city in South America, which had all the properties described by the ancients, as Pliny, &c. It even appears that some use is made of them in dyeing cotton on the coasts of Guajaquil and Guatimala.

The colours of the Portuguese men of war, or *holothuria physalis* of Linnæus, present, some of them a beautiful crimson, others a fine purple, and Dr. Bancroft procured a fluid of the same purple colour, with which he stained the corner of a cambric handkerchief that sustained nine months repeatedly washing without losing much of it's colour. This liquor was very acid.

It is observed by Martin Lister in the Philosophical Transactions, that the common hawthorn caterpillar will strike with lie a purple or carnation colour that will stand; likewise the heads of beetles and pismires will give an equally fixed carnation colour; and he adds, that the amber coloured scolopendra affords by means of lie a most beautiful amethyst colour equally durable, whilst eggs of a cimex bruised upon white paper, communicate alone a lively and bright vermilion colour.

From this account of the Tyrian purple, it appears that it is not lost; if, however, modern artists have neglected to procure it, if they have not endeavoured to profit from the essays already mentioned as made by their contemporaries, it is because colours have been acquired that are not only more beautiful but less dear. We have be-



sides what has been described a very detailed description of the manner in which the ancients fished for the shell fish that afforded the purple, in a work composed by Eudocia Macrembolitissa, daughter of the emperor Constantine the Eighth, who lived in the 11th century. This lady was an eye witness of the account she wrote.

Cochineal.

The insect from which that beautiful rich red colour called crimson is taken is of the order hemiptera, named by Linnæus, coccus cacti. According to Berthollet, it is sometimes oviparous, and at other times viviparous. The male only lives a month, which it ends with it's amours, and the female only survives him the following month, and dies after parturition. This insect is an inhabitant of the province of Mexico, and other Spanish parts of South America, where it is bred and collected in large quantities; the commerce it gives rise to being estimated at many millions of Dollars annually. It's food is the leaf of the Indian fig, or prickly pear tree, the cactus opuntia of Linnæus. It is likewise called nopal.

Where  
found.

In the country from which it is brought it is guarded with great care and jealousy, to prevent foreigners from transplanting it into other countries. Several attempts have, however, been made to procure it. Thiery of Menonville had the courage and patriotism to expose himself to the greatest risks, by going to Mexico to observe the education of this insect; and he was so fortunate as to convey this precious production into the island of St. Domingo; but no accounts have been lately received of it's prosperity.

When the females are scattered on the plant, and the young are observed to proceed from them, they begin their culture. They are afterwards killed by boiling water, and dried with great care in the sun, by which exsiccation they lose nearly  $\frac{2}{3}$  of their weight.

According to Spallanzani, in his travels through the

Two Sicilies, this insect might be advantageously transplanted to the Lipari islands and Sicily, where the plant they feed upon grows with more luxuriance than in South America.

From the external appearance of cochineal, and from the secrecy with which its nature was preserved, it was for a long time supposed to be the entire fruit or berry of the tree, that had been wrinkled and shrivelled by the drying, and when the fruit or pear was known, it was then supposed to be the seeds of it. It is a small, irregular, roundish body, and internally of a red colour. Acofta was one of the first eye witnesses of its being an insect; and Sir Hans Sloane, Plumier, and all the later travellers into America, confirm his account of it.

The dried cochineal is sorted into two kinds, viz. into the large entire grains, called by the Spaniards, *grana*, and into small or broken ones, which they call *granilla*. In trade, four sorts are distinguished: mesteque, campechane, tetræschale, and sylvester, of which the first is accounted the best, and called *grana fina*, and the last the worst, called by the Spaniards, *grana sylvestra*. The three former are named from the places in which they are produced; the latter, from its being found wild, without any culture.

It's varieties  
in com-  
merce.

According to Neuman, those sorts of opuntia, the fruit of which is of the deepest red colour, are observed to produce the finest cochineal; but although the colour of the fruit of this plant is red, we are informed by Thiery, that the juice which this insect feeds upon is greenish, and that it will live and perpetuate its species on those kinds of opuntia of which the fruit is not red.

The large or *grana fina* is not covered with a cottony down like the other, which down being useless in dying, equal parts afford more colour, and it is of a superior price to that of *sylvestra*; but, perhaps, these advantages

are opposed by it's more expensive education, and by it's having no down, which causes it not to resist the rain and storms so well as the other.

The grana *sylvestra*, raised from the nopal, loses in part the tenacity and quantity of it's cotton, and becomes double the size to what it does on the other species of opuntia. It is therefore to be hoped, that by a continued system of education, it will become more perfect, and approach by degrees the grana *finia*.

Properties  
of the best.

The fine, or best cochineal, when well dried and preserved, is somewhat heavy, moderately compact, clean, and of a glossy surface, of a gray colour, tending to a purple. The gray colour is owing to a powder which covers it naturally, and a part of which still remains; the purple shade is owing to the colour the water has extracted on destroying them. When chewed it tinges the spittle of a deep brownish red colour called crimson; and impresses on the organs of taste a kind of faint and not very agreeable savour. When thoroughly dry, it has no smell; when moist, it is somewhat musty.

This insect may be preserved a long time in a dry place. Hellot says, that he tried cochineal 130 years old, which was as good as new.

Experiments of  
Berthollet.

On comparing the *sylvestra* cochineal of Mexico, and some sent from St. Domingo by Bruley, with the *mesteque*, Berthollet found that the decoction of the *sylvestra* has the same shade as that from St. Domingo; that this shade tends more to the crimson than that of the *mesteque*; but the precipitates obtained either by solution of tin or by alum, are exactly of the same colour as that of the *mesteque*; and it is these precipitates, that, by combining with the stuffs, give them their colour.

In order to determine the proportion of colouring matter the decoctions of the different cochineals contained, this chemist made use of the oxygenated muriatic

acid. He boiled an equal weight of each of the three cochineals for one hour; he poured each of the decoctions, when filtered, into separate graduated glass cylinders, and then added oxygenated muriatic acid to them until the three were brought to the same yellow hue, and the quantities of acid that indicated the proportions of the colouring matter were found exactly as follows, viz. eight for the cochineal of St. Domingo; eleven for the sylvestra of commerce, and eighteen for the mesteque.

Hence the cochineal of St. Domingo is not only very inferior to the mesteque, but even to the sylvestra of Mexico, and in reality it is much more downy and smaller; but the observations of Thiery have proved, that the sylvestra, by a succession of generations, if carefully attended to, loses part of it's down, and becomes much larger; hence it is to be hoped, that the cochineal of St. Domingo may, by care, be brought to the state of perfection of the Mexican, and perhaps, to surpass it.

Water, by decoction, extracts some of the colouring matter of cochineal; and the colour, according to Berthollet, is of a crimson, inclining to a violet. Water, however, does not extract all, and the remaining colouring matter, Dr. Bancroft found to be extracted (which is about  $\frac{1}{8}$  of the whole) by the addition of soda to the residuum, and a fresh supply of boiling water. If this be evaporated, and the extract digested in alcohol, the colouring parts are dissolved, and afford a residuum that only retains the colour of wine lees, of which a new addition of alcohol cannot deprive it. This part, on analysis by fire, affords the same products as other animal substances.

The alcohol of cochineal, on being evaporated, leaves a transparent residuum of a deep red colour; which, when dried, has the appearance of a resin. It gives likewise on distillation, the products of animal substances, a con-



vincing proof that this colouring matter is an animal production.

The decoction of cochineal enters, with difficulty, into putrefaction; and on preserving it more than two months, both exposed to the air, and in a closed bottle, the first presented no symptom of putrefaction; the second had a slight putrid odour. The first became turbid almost at the beginning, and left a brown violet sediment on the filter; the second preserved it's transparency a long time, and, perhaps, only lost it from the effect of the incipient putrefaction, or rather, according to Berthollet, from a slight combustion that was occasioned by a little oxygen that had probably united to the red particles of the cochineal. The colour of both had become crimson, the first, however, was weaker from the greater part of the colouring particles being precipitated in consequence of certain effects produced by the air.

Berthollet, on trying the different effects which a variety of chemical agents had upon the colouring matter as it existed in the decoction, found, that the sulphuric acid in small quantity gave this liquor a red colour tending to a yellow, and a beautiful red precipitate fell to the bottom.

The sulphat of soda produced no evident change.

The sulphat of iron formed a brown violet precipitate, and the liquor remained clear, with a tinge of dead leaf (*feuille morte.*)

The sulphat of zinc produced a deep violet precipitate, and the liquor remained clear and colourless.

The sulphat of copper produced a violet deposit, that was very slowly formed, and the liquor remained clear, and of a violet colour.

The muriatic acid produced nearly the same change as the sulphuric; but without any precipitation.



A solution of muriat of soda gave a deep rose coloured precipitate without rendering the liquor turbid.

Muriat of ammoniac produced a shade of purple, without any precipitation.

The acetite of lead produced a purple violet coloured precipitate, but less deep than the sulphat of zinc; the liquor remained limpid.

A solution of tartar changed the liquor to a yellowish red, and a small precipitation took place of a pale red colour, whilst the supernatant liquor remained yellow. On pouring a little alkali into it, it became purple. The alkali rapidly dissolved the small quantity of precipitate, and the solution was purple. A solution of tin formed with the yellow liquor a rose coloured precipitate.

Having boiled a little cochineal with half it's weight of tartar, the liquor became more red, and had a much less deep colour than an equal quantity of cochineal without tartar; but the first gave, with a solution of tin, a more abundant precipitate, more of a rose colour, hence tartar favours the solution of the colouring parts of the cochineal; and although the colour of the solution be less deep, the precipitate produced from it by the solution of tin has a deeper and more rosy hue. This experiment, Berthollet thinks, deserves some attention, in order to judge of the influence of the tartar in the process of dying scarlet.

A solution of tartar being poured to the liquor of decoction, and afterwards a solution of tin, a deposit was more readily formed than by tin alone, which was of a rose colour tending to a lilac, and although an excess of the solution of tin was added, the liquor remained somewhat yellow.

A solution of alum brightened the colour of an infusion of cochineal, and gave it a redder hue, a crimson

precipitation took place, and the liquor retained rather a reddish crimson colour.

A mixture of alum and tartar produced a brighter colour, more lively, and tending to a yellowish red; a precipitation took place, but much less in quantity, and much more pale than in the preceding experiment.

A solution of tin formed a large deposit of a beautiful red colour; the liquor was clear as water, and no change of colour took place on the addition of an alkali.

Dr. Bancroft.

For a more extensive investigation of the colouring matter of cochineal, and the various colours produced upon it by different agents, we are indebted to the labours and investigation of Dr. Bancroft. He has particularly paid attention to the method of producing, with this colouring matter of cochineal, which is naturally a crimson, that most beautiful and splendid of all others, the scarlet colour, the richest of any that the art of dying has been able to produce. The shades of this scarlet colour are known to be various, from a more or less deep red, to a more or less vivid fire coloured scarlet; but as the common operations were insufficient to produce these shades, other experiments were necessary, which appear to have been made with great accuracy.

Discovery of scarlet.

It is most probable, for many years, that cochineal was made use of in Europe as a dye, the aluminous basis was the only mordant employed for this purpose. An opportunity, however, accidentally occurring to Keppler, a German chemist, of seeing the wonderful effects of a solution of tin by the nitrous acid in exalting the colour of this substance, the discovery of the cochineal scarlet was the consequence. Keppler, or as he is sometimes called, Kuster, brought his secret to London, in 1543; such is the account which Kunckel gives of the discovery of his countryman.

It has been generally supposed by writers on this subject, that after the effect of tin upon the cochineal colour had been discovered, nothing was wanting to produce scarlet than to apply the colour so produced, as a dye to wool; or in other words, that a nitric or nitro-muriatic solution of tin was sufficient to change the natural crimson of cochineal to a scarlet. This, however, Dr. Bancroft esteems as an erroneous opinion, for this solution only produces a crimson or rose colour, and not a scarlet, unless other means be employed to incline the cochineal colour, as far as may be necessary, toward a yellow hue; and the means of doing this seem to have been stumbled upon without any knowledge of their real effect. Tartar was, and is the usual mordant for the dying of woollen cloths, as it gives the cochineal the yellowish tendency necessary to produce a scarlet. This chemist found, on inquiry, that scarlet was a compound colour, consisting probably of  $\frac{3}{4}$  of a most lively pure crimson or rose colour, and  $\frac{1}{4}$  of a pure bright yellow. Now the great desideratum was, to find out a yellow from other drugs, equivalent to the conversion of  $\frac{1}{4}$  of the cochineal colouring matter from it's natural crimson to the yellow colour. The muriatic solution of tin appeared the best as a mordant, as it fixed and reflected the pure crimson or rose colour of the cochineal unchanged and with the utmost brightness. Alum, though it fixes it's colouring particles more durably, degraded or altered the natural colour of the cochineal solution, as well as solutions of all the earths and metals, tin excepted. To produce a scarlet, therefore, it was only necessary to superadd and intimately combine with this crimson or rose colour, a suitable portion of a lively golden yellow, capable of being properly fixed and reflected by the basis. Such a yellow Dr. Bancroft found in the quercitron bark (*quercus nigra* Lin.) and in young fustic (*rhus cotinus* Lin.) although

A compound colour of crimson and yellow.

Produced by quercitron bark,

and muriatic  
sulphuric  
solution of  
tin

the last is much less bright and less durable. The quercitron bark is not only the brightest but the cheapest of all yellows; for according to this chemist, 1 pound of the powdered bark, which only cost three pence farthing, with a sufficient quantity of muriatic of tin, dyed between 30 and 40 pounds of woollen cloth of a full bright golden yellow, and this being afterwards dyed in the same liquor with  $\frac{1}{4}$  less of cochineal than what is usually employed, acquired a scarlet equal in beauty and durability to any that is usually given by ordinary means with a full proportion of cochineal. He found that three pounds of muriatic acid, which only cost one shilling, might be made to dissolve a pound of tin, that would require eight pounds of single aqua fortis to dissolve; and that the muriatic had likewise this advantage, that a solution made by it was as transparent and colourless as the purest water, and capable of being preserved for many years without the least alteration, whilst the nitro-muriatic solution of tin, or spirit of the dyers, becomes turbid and gelatinous very speedily, and even in a few days if the weather be warm; it may also be added, that the muriatic solution seems to exalt the colour both of the quercitron bark and of the cochineal more than any other. He likewise saved all the tartar employed in the old process, and extracted, by potash, a part of the colouring matter of the cochineal, supposed to have been before always lost, and obtained by means of the bark, as much yellow as was required for the composition of this colour with the cochineal crimson, instead of converting any part of this last more costly colour into a yellow. He found, however, that the muriatic of tin possessed a very corrosive property; hence he used the nitrate of tin, which he found, contrary to his expectation, (when unmixed with tartar) only to produce a crimson, but that if tartar was employed either with the muriatic or nitric solutions of the metal, a scarlet colour was the



consequence. The contrary to this was the general opinion; for according to Berthollet, tartar gives a *deeper* and more *rosy hue* to the colouring matter of the cochineal, precipitated by the solution of tin, and it moderates the action of the nitro-muriatic acid, which tends to give scarlet an orange cast. After various experiments, therefore, Dr. Bancroft found, that the best was a solution of about fourteen ounces of tin in a mixture of 2 pounds of oil of vitriol with three pounds of muriatic acid. The muriatic acid is to be first poured upon a large quantity of granulated tin, in a large glass receiver, and the oil of vitriol afterwards added slowly; these acids being mixed are left to saturate with the tin; this solution is more rapidly promoted by a sand heat. This murio-sulphuric solution of tin is perfectly transparent and colourless, and remains so many years; it produces full twice as much effect as the dyers spirit or nitro-muriatic solution of tin, with less than  $\frac{1}{3}$  of the expense. It raises the colour more than the dyers spirit, and full as much as the tartrite of tin, without changing the natural crimson of the cochineal towards the yellowish hue, and is the best mordant or basis for producing a compound scarlet, with the cochineal, crimson, and quercitron yellow, in which operation  $\frac{1}{4}$  of the cochineal may be saved. To this it may be added, that by using the quercitron bark, not only  $\frac{1}{4}$  of the cochineal is saved, but the scarlet composed of these two may be dyed upon woollen and linen yarn without any danger of it's being changed to a rose or crimson by the process of fulling, as always happens to scarlet dyed by the ordinary means, and if it be compared with the common scarlet by candle light, it appears at least to be several shades higher and fuller, and is not to be spotted or changed by chemical agents, such as calcareous earth, soap, alkaline salts, &c.



The process.

The process is to put the cloth to be dyed scarlet into a proper tin vessel nearly filled with water, with which about eight pounds of murio-sulphuric solution of tin have been previously mixed; the liquor is then boiled, turning the cloth through it as usual for  $\frac{3}{4}$  of an hour, the cloth being then taken out, four pounds of cochineal and two pounds and a half of quercitron bark, are to be added in powder; having mixed them well, the cloth is to be returned into the liquor, the boiling and operation continued until the colour is duly raised, and the dying liquor exhausted, which is in about fifteen or twenty minutes; the cloth is then taken out and rinsed as usual. By this method the time, labour, and fuel necessary for a second process will be saved, the operation finished more speedily, and a saving of all the tartar,  $\frac{2}{3}$  of the cost of spirit or nitro-muriatic solution of tin, and  $\frac{1}{4}$  of the cochineal usually employed, and the colour is not inferior to that dyed in the ordinary way; and as to the scarlet, every possible shade between the crimson and the yellow colours may be produced by only increasing or diminishing the proportion of bark. If a crimson or rose colour is wanted the bark is omitted.

Effects of metallic and earthy bases on the colouring matter of cochineal.

It remains to give an account of the experiments Dr. Bancroft made to discover the effects which metallic and earthy bases have upon the colouring matter of cochineal.

1. Effects of metallic bases upon woollen cloths with the colouring matter.

The nitro-muriat of platina produced with cochineal, a red, which by the addition of chalk, became a chestnut colour.

Cochineal with nitro-muriat of gold, a reddish brown.

With nitrat of silver, a dull red, and with muriat of silver, a lively reddish orange.

All the preparations of copper appear to sadden and debase the colouring matter; and those of mercury, in a

much greater degree, and they appear likewise to annihilate a considerable part of the colour as well as debase it:

With the acetite of lead, a purple colour, inclining to the violet, is produced. With nitrat of lead, a delicate lively colour, between red and cinnamon, but more inclining to the formèr. A little murio-sulphat of tin added to the last, changed it to a good crimson.

With either the sulphat, nitrat, muriat, or acetite of iron, a dark violet, and even a full black colour is produced, when the cochineal is in sufficient quantity.

The oxyd of tin (förmèd by means of aqua fortis) with an equal quantity of cochineal, gave, on boiling, a full equal crimson, somewhat deficient in brightness! Tartar or lemon juice being added, a good scarlet was produced. By substituting caustic volatile alkali for these two last, there arose a crimson colour, greatly inclining to a purple. Hence Dr. Bancroft is of opinion, that the oxyd of tin does not act in all cases, *merely as such*, but it's effects often depend on triple, quadruple and sometimes even more complex combinations, in which different saline and other parts of the compound remain permanently united, at least where the shades of colour depending on them are found permanent. Hence sea salt, and other purely saline matters, having no earthy or metallic basis, cannot become the basis of any adjective colour, but produce *lasting* effects in modifying and varying the complexions of different colours. It must, however, be observed, that this oxyd, although after being well washed and dried, it was capable of dying a crimson on woollens with cochineal, and a scarlet, where either tartar, lemon juice, or quercitron bark were added, would not permanently combine with, or become the basis of these colours upon cotton; and on woollen it was only the finer particles of the calx that really combined with the colouring matter and the wool, the grosser being always distinctly

found at the bottom of the vessel; it is likewise necessary that the oxyd and the colouring matter should be previously mixed together, and exert their mutual attractions upon each other before they can be properly taken up by the cloth.

Cochineal with nitrat of tin produced a fine crimson, and when the cloth was boiled in the same with tartar, it was changed to a good scarlet. Tin dissolved immediately in a mixture of aqua fortis and tartar produced a scarlet much more and highly beautiful. Refined sugar or alcohol added in the formation of nitrat of tin rendered the solution unfit to combine with the fibres of the cloth, or serve as a mordant.

With a solution of tin by muriatic acid, it dyed a beautiful crimson, and with a solution of that metal, by a mixture of tartar and muriatic acid, a beautiful scarlet. The acid of tar added with the muriatic solution, produced a dark crimson; and with tin and a little manganese in the muriatic acid, a very bluish crimson. Borax with the muriatic solution of tin, dyed a very good crimson.

With tin calcined by the long continued action of sulphuric acid, it dyed a salmon colour; and with a recent solution, a reddish salmon colour, inclining a little to the crimson. The same colour was produced with tin dissolved in equal parts of sulphuric and nitric acids. Oil of vitriol poured on tartar and granulated tin became black, and this tartaro-sulphuric solution with cochineal gave an aurora colour.

With a solution of tartrit of tin a very beautiful scarlet was produced, inclining a little to the aurora. A similar colour was made by water saturated with cream of tartar in which granulated tin had been kept six weeks.

With the citrat of tin, a scarlet of which nothing can exceed the beauty, and inclining like the preceding, a

little to the aurora. This citric acid with tin is found to act at least as efficaciously as that of tartar, in yellowing the cochineal crimson.

With acetite of tin, a scarlet inclining a little to the crimson; the solution had an unpleasant smell.

With tin dissolved by acid of tar, a colour was produced between the scarlet and crimson shades.

With phosphat of tin, an aurora colour.

With fluat of tin, a very good scarlet.

Cochineal, with nitrat of zinc, produced a lively strong lilac colour.

With muriat of zinc, a colour like the preceding, but inclining a little more to the purple. Dr. Bancroft thinks that probably the iron usually contained in zinc may have contributed in these instances to incline the cochineal crimson so much to the blue or violet shades, since a purer oxyd of zinc, the lapis calaminaris, dissolved in muriatic acid gave a scarlet with cochineal, but very little inferior to that commonly produced by the nitro-muriat of tin and tartar, and upon adding a little murio-tartrit of tin to the dying liquor, a very beautiful scarlet was the consequence; hence the pure oxyd of zinc appears to this chemist to approach nearest to that of tin, in exalting the colouring matter of cochineal.

With different solutions of bismuth, various shades of lilac were produced, some of which were very lively and delicate; but all the preparations of this semimetal, instead of displaying and exalting the cochineal colour, tended to render a part of it latent. The acetite of bismuth did this less than most of them, it gave a pretty good purple, and the murio-sulphat of bismuth a salmon colour.

With nitrat of cobalt, a good purple was produced.

With nitrat of nickel, a dark lilac, inclining to the violet.

With sulphat of manganese, an orange colour, with nitrat of manganese, a colour resembling the madder red.

With a solution of crude antimony in nitric acid a scarlet was produced, very much like that with lapis calaminaris in the muriatic acid, and very little inferior to the best scarlets given with the tin basis.

With the acidulous arseniat of potash, or Macquer's arsenical neutral salt, a lively good purple colour was produced.

2. Effects of several kinds of earths as bases for the cochineal colouring matter upon wool.

Alumine well washed, dried and finely powdered, appeared incapable of fixing or serving as a basis of the cochineal colour, hence it differs materially from the powdered calx of tin. The same pulverized alumine, however, boiled with cream of tartar, was so far dissolved by the acid as to produce a good crimson, though not much better than that produced with the sulphat of alumine or common alum. This alumine dissolved by lemon juice dyed a very good rich full crimson. Dissolved by nitric acid, a good red colour, inclining to crimson. In muriatic acid, a crimson very little different from that produced with common alum.

Lime-water with cochineal dyed a purple, which took but slowly, and required long boiling. Sulphat of lime dyed a full dark red. Nitrat of lime, a lively red, approaching to a scarlet. Dr. Bancroft found that cloth boiled in water with nitrat of lime, and then dyed in clean water with cochineal and tin, dissolved by aqua fortis and tartar mixed, received a good scarlet. Muriat of lime dyed with cochineal a purple. Cloth boiled with chalk and alum, and then dyed in clean water with cochineal, took a good crimson, inclining to the bluish shade.



Sulphat of barytes not being soluble in water could not be tried. Muriat of barytes dyed a good lively purple with the cochineal, and nitrat of barytes nearly similar, but inclining a little more to the crimson.

Magnesia alone did not serve as a mordant. The sulphat of magnesia (Epsom salt) dyed with cochineal a lively purple, though it took but slowly, and required long boiling. Acetite of magnesia gave a lilac colour.

Siliceous earth or powdered flints with pure potash, and dissolved in a crucible by a violent heat, appeared at first not to have sufficient affinity for the fibres of the cloth and the colouring matter, but on adding a little sulphuric acid, so as to deconipose and neutralize a part of the alkali, combined with the siliceous earth, the colour took freely and rose to a *full rich pleasing purple*, in which the red or crimson predominated considerably, and this colour proved afterwards sufficiently durable.

Hence it appears, that besides the metallic oxyds and solutions, the aluminous, calcareous, siliceous, magnesian and barytic earths are capable of fixing and serving as bases of the cochineal colouring matter.

### 3. On silk,

Dr. Bancroft repeated nearly all the foregoing experiments with silk, instead of wool, but found that in general the effects were less advantageous. Cochineal indeed, with the aluminous basis, dyes the crimson colour as well and as durably on silk as on wool, and the modes of producing a very lasting crimson by these means are well known. The oxyds or solutions of tin, however, do not fix and reflect the cochineal colour on silk with the same degree of fulness and lustre as upon wool; probably because the former of these substances has less attraction than the latter for the calx of tin and the colouring matter of cochineal combined together; hence it

Dying of  
silk and  
wool.

has been found impossible to dye a good lively scarlet on silk, by the means which communicate that colour to wool.

This chemist, however, has given the following method of producing a scarlet on silk. The silk is to be soaked for two hours in the murio-sulphuric solution of tin beforementioned, with five times it's weight of water, then taken and moderately pressed, then partly dried, and dyed as usual in a bath of cochineal and quercitron bark, four of the first to three of the second, and it will receive a colour very nearly scarlet. This may be made to receive more body by a farther slight immersion in the mordant, and a second dying in the bath; and if afterward a little of the red colouring matter of the safflower be super-added in the usual way, a good scarlet may be produced. By omitting the bark and dying the silk (prepared as before) with cochineal only, a very lively rose colour will be produced, and this may be yellowed so as nearly to approach the scarlet, by a large addition of tartar to the cochineal in the dying vessel.

With lime-water as a mordant cochineal gave to silk a very agreeable purple; with muriat of barytes, a lively delicate lilac colour; with murio-sulphat of bismuth, a salmon colour; with nitrat of cobalt, a very lively and beautiful purple; and with nearly all the other metallic and earthy bases, cochineal produced similar but paler colours on silk than on wool.

Cotton.

4. On cotton. It appears that animal colouring parts have much greater attraction for the fibres of animal fluids than for those of the vegetable kingdom; hence the small affinity the colouring matter of the cochineal has for cotton, and it is the same with the other animal colours. It is owing to this weaker attraction that the scarlet dye is so much less permanent on cotton than on wool; that the first takes it more slowly, and that it is

much paler than the second; and it is also from this want of sufficient attraction, that the colouring matter of the cochineal is found to act most beneficially on cotton, when the basis has been *first applied separately*.

The method of dyeing cotton scarlet, recommended by Dr. Bancroft, is to soak the cotton (previously moistened) for half an hour in a diluted murio-sulphuric solution of tin, as proposed for silk; the superfluous part of the solution is to be wrung out, the cotton then to be plunged in water, in which as much clean potash has been dissolved as will neutralize the acid still adhering to the cotton, by which the oxyd of tin will be set free, and more copiously deposited or fixed in or upon the fibres of the cotton, which being afterwards rinsed in clean water, may be dyed with cochineal and quercitron bark, about four pounds of the former to two and a half or three pounds of the latter. By this means a full bright colour may be given to the cotton, which will bear a few slight washings with soap, and a considerable degree of exposure to the air.

Cochineal will give cotton, previously impregnated with the aluminous mordant, a very beautiful crimson colour, capable of bearing several washings, and of resisting the weather for some time, though not long enough to deserve being called a fast colour.

This chemist found that a strong decoction of cochineal, thickened with gum, and mixed with a suitable proportion of nitrat of alumine, being penciled upon cotton as a profubstantive colour, afforded a very full beautiful crimson, which stood some washings, and a considerable degree of exposure to the weather.

Several of the different solutions of tin being employed, instead of the nitrat of alumine, produced very beautiful reds; between the crimson and scarlet, and by a small proportion of quercitron bark they were made scarlet.

These are not fast colours, but are much more lasting than some of the fugitive colours too often made use of.

**Carmine.** Carmine was formerly prepared from kermes, from which it takes it's name; it is now the lake obtained from cochineal by means of alum; a certain proportion of *autour* is mixed with the cochineal, a bark brought from the Levant, and of a paler colour than cinnamon; some *chorcan* is likewise generally added, which is a yellowish green seed of an unknown plant, growing also in the Levant. It appears to Berthollet, that in this process these two substances produce with the alum a yellow precipitate, which serves to brighten the colour of the cochineal lake, in the same manner as a yellow colouring matter serves to give scarlet a fine colour.

**Kermes.**

## 2. COCCUS ILICIS OR KERMES.

It's antiquity.

THIS appears to be the species of coccus that was used by all the nations of antiquity, and professor Tychsen even conceives that it was known to Moses under the name of tola. It was then employed for giving the ground to cloths intended to be dyed with the rich purple. It was known to the Greeks and Romans by the name of *coccum squarlatinum*, *coccus baphicus*, *infectorius*, *granum tinctorium*; and the preference was given to that collected in Galatia and Armenia. It therefore appears to have been one of the most ancient of all dying drugs, and that which produced the colour called coccus by the Romans, and originally known in England by the name of scarlet.

It's etymology.

With respect to it's etymology, according to father Plumier, it arises from the Arabic word *kermen* or *kermes*, which signifies a little worm, and is the name of this in-

fect. From it's Latin appellation *coccus* arose the Spanish diminutive *coccinella*, *cochineal*, and from it's Arabic name arose the colour *cramoufi*, in French *crimson*. In the middle ages it was called *vermiculum*, whence *vermeil* and *vermilion*, although now applied to pulverized *cinnabar*. *Astruc* derives it from two Celtic words signifying *oak* and *acorn*.

The *kermes* is an insect found in several parts of Asia, <sup>Whence collected.</sup> in the Levant, Spain, France, and other southern countries of Europe. It is now chiefly collected in Languedoc, Spain and Portugal. It lives on a small species of oak called the *quercus coccifera* by *Linneus*, or the holm oak. The female having no wings, fixes herself amongst the leaves of this tree, where the male comes to impregnate her. Having become big, she gets sluggish and remains motionless, brings forth and dies. In the pregnant state she soon loses the form of an insect, and appears like a small roundish grain, about the size of a pea, of a reddish brown colour, resembling a brown red cap, in which are enclosed a very great quantity of eggs of a deeper red colour.

From the form of this insect, the *kermes* was for a long time taken for the seed, or an excrescence of the tree on which it lived, and they were called grains of *kermes*. It appears that *Pliny* was of this opinion, that it was an excrescence, although he mentions it as speedily becoming a worm; "*coccum ilicis celerrimè in vermiculum se mutans.*" The Roman natural historian, indeed, inaccurately describes it's colour to be a species of rose, whereas in fact it is a red, approaching nearly to that of florid arterial blood.

The first who has spoken of this insect with any exactitude is *Peter de Quinquernan*, bishop of *Senez*, in a work entitled, *de Laudibus Provinciæ*, published in 1530. It's history may be likewise seen written by *Nissole*, in the *Memoirs of Acad. des Sciences* for 1714.



and more particularly in the *Memoires des Insectes de Réaumur*; tom. iv.

The kermes is fixed to the bark of the shrub by a cottony down, the production of the insect. Chaptal has observed that this down, as well as that afforded by all other insects of this genus, possesses several characters of the caoutchouc or Indian rubber, that it is insoluble in alcohol, that it melts at a boiling heat, and that it burns on the coals with a flame. According to the manner of collecting this insect, we are informed by Berthollet, to whom Chaptal sent the account, that a single person is able to gather one or two pounds per day. They begin to collect towards the middle of the month of May, when the insect has attained it's ordinary size, and the harvest continues to the middle of June, and sometimes longer. They are generally collected by women. At the beginning, from the juice of the fresh kermes weighing heavier than at the end when it is drier and light, it only sells for 15 or 20 sous per pound, whilst when the harvest is nearly over it fetches from 30 to 40. Those who buy it are obliged as soon as possible to prevent the hatching of the eggs. In order therefore to destroy the young, they steep the kermes for 10 or 12 hours in vinegar, or expose it to the vapours, which only takes up half an hour; it is then dried on linen cloths. This process gives it a vinous red colour.

It's properties in dying.

According to Lewis and Berthollet, fresh kermes, or the living insect, by expression affords a red juice, which has rather an agreeable odour, and a somewhat bitter, rough, and pungent taste. In it's dried state, it imparts the same odour and flavour to watery and spirituous liquors, to which it communicates it's deep red colour. The extracts obtained from these tinctures by inspissation retain their colour and lose very little of their flavour, but the aqueous extract loses all it's smell. The

mordants for this colouring matter of kermes are alum and tartar; in order to prepare the wool for the kermes dye, it is to be boiled in water with about one fifth it's weight of alum, and half as much tartar, for two hours, and then left in the same liquor four or five days, when being rinsed, it is dyed in the usual way with about 12 ounces of kermes for every pound of wool. These scarlets were called *grain colour*, from the insect being mistaken for a grain; and Venice scarlet, from being principally manufactured at Venice. Wool prepared with a nitro-muriatic solution of tin (as is done for the cochineal scarlet) and dyed with kermes, takes a kind of aurora or reddish orange colour.

The red colour that kermes communicates to wool has less splendour than the scarlet of the cochineal, which last Compared with cochineal. has been generally preferred to it, since the art has been known of using the solution of tin; but although the kermes red or scarlet is less vivid, it is more durable than that of cochineal, and much less liable to be changed by soap, acid, mud, &c. hence grease spots may be effaced without changing it. The fine blood reds seen at this time on old tapestries, in different parts of Europe, as for instance, those at Brussels, observed by Hellot, and at the other manufactories of Flanders, were all dyed from kermes, with the aluminous basis, on woollen yarn, and they are still unfaded, having scarcely lost any of their liveliness, although many of them have stood between two and three hundred years. From the solidity of this dye, it is to be regretted that it is abandoned by the dyers; some, indeed, mix a small quantity of it with the cochineal, as it gives a greater body to the colour; but it diminishes it's bloom.

According to Berthollet, the colour produced by half kermes and half madder is called scarlet in half grain. This mixture affords a very permanent dye, but is not

lively, and inclines a little to the blood red. The turbans manufactured at Orleans, for the Levant, are said to be dyed in this manner, although a little Brasil wood is probably added.

Dyers have only been able to give silk, with kermes, a dull reddish colour.

According to Bancroft, cotton prepared with the aluminous mordant, and dyed with kermes, exhibits a fine red, inclining to the crimson shade; but this will gradually though slowly discharge, and the colour be weakened in washing. This chemist is in hopes of succeeding in fixing the colour of kermes more permanently on cotton.

Lac.

### 3. COCCUS LACCA.

GUM LAC, as it is improperly called, is a species of wax which forms the cells of a certain insect called *coccus lacca* by Linnæus, and the beautiful red colour is owing to the insect; if, however, the insect has left it, which it does by piercing a hole at the top of the cell, the lac is no longer of that red colour, is of no use in dying, and is only employed for varnishes. The insect is an inhabitant of the East Indies, inhabiting, according to Ker, the uncultivated mountains on both sides of the Ganges, where it is produced in such abundance, that was the consumption ten times greater than it is, the markets might be well supplied by this minute insect. The price at Dacca is about twelve shillings the hundred pound, although it is brought from the distant country of Assam.

Whence  
brought.

This author informs us, that this insect, in the country

where he was, is found on four species of shrubs, viz. on the *ficus religiosa* Lin. the *ficus indica* Lin. the *plaso Hortus Malabaraci*, and the *rhammus jujuba* Lin.

The insects of this species fix themselves in such multitudes on the branches of these trees, and more especially on the three first, that the extreme branches appear as if they were covered with a red dust that destroys both trees and fruit. Birds perching on these branches likewise carry off great numbers of the lacca insects adhering to their feet, and thus transplant them, by depositing them on other trees where they rest. Of these four species of trees, it appears, there is only one, the *rhammus jujuba*, upon which Dr. James Anderson found these insects near Madras, although he observed them on several species of mimosa, and on some other trees and shrubs. Dr. Roxburgh of Samulcotta, however, seems to think, that on the coast of Coromandel they only inhabit shrubs of the mimosa kind, and even but three species of this genus. This last gentleman has given a description of the nature and progress of these insects, with great minuteness, in the *Philosoph. Transf.* for 1791. The gum lac is distinguished by several names: thus, in it's most natural state, or adhering externally to the small branches of the shrub, it is called *stick lac*; when it is detached from these and reduced to a gross kind of powder, *red lac*; when liquified and made into cakes, *lump lac*; and when the seed lac is deprived of it's colouring matter, and formed into thin transparent plates, it is called *shell lac*. Dr. Roxburgh is of opinion, that the colour should be extracted from fresh lac instead of dry lac, in the month of October, or beginning of November, before the insects have acquired life, as he found the 'deepest and best colour to be produced from the eggs when mixed with the

It's varieties.

nidus, whilst the dried lac communicates a much less bright colour to water.

Bancroft's  
method of  
extracting  
the colour  
from it.

According to Bancroft, the colouring matter may be got from this drug in the form of extract, by boiling it in water, then by filtration and evaporation.

Compared  
with cochineal.

The colours dyed by *Stick lac* approach very nearly to those of cochineal. They are not quite so lively and beautiful; but this defect is in some measure compensated by their being more durable, especially on cottons. It requires the same basis and treatment as cochineal. It is used by the natives of India as a dye; and according to Sir William Jones, the Hindus have six names for lac, although they generally call it *lacsna*, from the multitude of small insects, which they believe discharge it from their stomach, and at length destroy the tree on which they form their colonies. It was likewise in use as a dye amongst the ancients. The moderns use it as the basis of sealing wax; and the greater part that comes to Europe is afterwards sent to Portugal, Barbary, &c. where it is employed in staining goatkins to make what is called red Morocco leather.

Used in  
sealing  
wax.

Examined  
chemically.

Neuman looked upon gum lac as a very hard sort of wax, tinged with an animal red, of the cochineal kind; he found, that the seed lac does not dissolve in water or in oils. To alum water it afforded a beautiful transparent red. Dr. Bancroft likewise found the colouring matter he received from the East Indies, which most probably was of this species, to be insoluble in water, which he attributes to its being too intimately united to a portion of alumine, employed in India to precipitate it, as a little pearl ash brought about its solubility. Neuman found, that of the concentrated acids, the vitriolic extracted very little of it, the marine somewhat more, and the nitrous nothing. Spirit of wine, after some time, dis-



solved nearly the whole of it, and the solution was of a brown colour. Distilled in the open fire, a thick empyreumatic oil was obtained, similar to that of common wax, after which arose an aqueous liquor, not manifestly acid, or alkaline. There remained a residuum.

Fourcroy looks upon it as a true wax, although he thinks it's dryness, the aromatic odour it exhales in burning, and it's solubility in spirit of wine, indicate a resemblance between it and the resins. By distillation, he found it afforded a kind of butter.

#### 4. COCCUS POLONICUS.

THE *coccus tinctorius polonicus*, as it is called, is a small round insect, about the size of a coriander seed, of a purple brown colour on the outside, and full of a blood red juice, which has been used in dying. It is collected in considerable quantities in waste sandy grounds in the Ukraine, and other provinces of Poland, and in the great duchy of Lithuania, where it is found adhering to the roots of the German knot grass or knawel (*sceleranthus perennis*.) It is gathered towards the end of June. It appears to have properties resembling those of kermes, but since the cheaper and more beautiful colours of cochineal have become generally known, it has been laid aside as well as the kermes. It was formerly very much used by the Turks and Armenians to dye wool, silk and hair, as well as in the staining the nails of women's fingers. This colouring matter was fixed on wool and silk by the usual mordant or preparation of alum and tartar.

*Coccus polonicus.*

Where collected.

Compared with kermes.

Nearly resembling the *coccus polonicus* is an insect which in many parts of Europe was formerly taken from

Other insects used in dying.

the roots of the burnet, (*poterium sanguisorba*, Lin.) and used in different countries, particularly by the Moors, for dying silk and wool of a crimson or rose colour. To this may be added the *coccus uvæ ursi*, Lin. which is likewise an insect affording a fine red colour, and it has the advantage of being nearly twice the size of the polonicus.

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—Observ. sur la Phosphore des vers luifans, &c. par id.  
id. T. 34. p. 187. an. 8.—Exper. et observ. sur la  
Phosphorescence de Lucioles, *Lampyrus Italica* par id. id.  
T. 26. p. 96. 1798.—Sur quelques Modifications de la  
Lumière, par le Cit. Brugnatelli, id. p. 107.

## CONCRETIONS.

Animal  
concretions.

IN this class of animal substances are comprehended all those more or less solid concretions which are formed in the different parts of animals, and which, as they are generally found either in the reservoirs or ducts of the different secretions or excretions, are supposed to originate in consequence of the fluids being secreted in a diseased state. The advantages that may arise from the analysis of such substances are expected to be,

The use of  
their ana-  
lysis.

1. To afford the physiologist a more accurate knowledge of the animal mechanism, by showing him the principles upon which they are formed, and the circumstances that give rise to them.

2. To assist in that investigation which is necessary to arrive at the cure of the diseases they produce, and often attended with the greatest danger.

For the best analysis of many of the substances of this class we are principally indebted to the labours of Scheele, who first thoroughly investigated one species of calculus; to Fourcroy, to whose skill in this part of science animal chemistry owes so much, and to Drs. Woollaston and Pearson.

## CALCULUS VESICÆ, OR STONE OF THE BLADDER.

OF all the hollow viscera, it is the human bladder in which calculous concretions are the most frequently and abundantly found, and according to Fourcroy, it is a remarkable fact, that they differ more by their volume,

their weight, their form, and their colour, than by their component parts, as appears from the result of all the experiments of modern chemists on this subject. With respect to their external properties, we are informed by Baillie, that when there is only one calculus present in the bladder, it is usually of an oval form, but when there are more, as is generally the case, they acquire by friction flat sides and angles. The vesical calculi have sometimes a smooth uniform surface, but more frequently granulated, so that they appear more or less rough; some have an irregular porous structure on the surface, instead of being granulated. When divided by the saw or broken, they exhibited most commonly a laminated structure. These laminæ are disposed in concentric curves, and are applied together with more or less compactness, and they differ in thickness in different calculi. The laminated structure sometimes pervades uniformly the whole mass of the calculus, at other times, different portions of it are interrupted by a coarse porous texture. In some calculi there is no laminated strata, but they are entirely porous. Their colour varies considerably; they are most frequently of a brown colour, of a lighter or darker shade, sometimes they are white, sometimes of a yellowish colour, and different portions of the same calculus are frequently of a different colour; some laminæ, for instance, are perfectly white, while the others are brown; in this sort of mixture Baillie has most commonly found the white laminæ on the outside, and the brown in the middle, nor does he recollect seeing one instance of laminæ of different colours disposed in alternate strata. Although the matter of the calculus is generally formed into one or more circumscribed masses, yet it sometimes happens that the whole bladder is filled with a substance like mortar.



Opinion of  
the ancients.

If we ascend to antiquity for the ideas entertained on the calculi of the bladder, we shall find, that the ancients looked upon them as mere stone or gravel, judging of them according to their external resemblance; hence this calculus was called by Aretæus, and Aurelianus, among the Greeks, λίθος and λιθιασις; by Celsus and Pliny, among the Latins, calculus and sabulum. Indeed it was supposed by Galen, that a viscid animal matter was the basis of these concretions; but in his days, earth was looked upon to be the basis of all animal matter; the Greek physicians, however, employed alcalis to cure these diseases.

Paracelsus.

On descending to more modern times, we find that the ideas of physicians respecting these substances, although they differed, were far from the truth; thus Basil Valentine looked upon them to be tartar, and Paracelsus, as intermediate substances between tartar and stone, of which the animal resin formed the first matter; and he admitted of no difference between the calculi of the bladder, which he called by the barbarous name of *dueleck*, and arthritic or gouty concretions, except that the first was hardened by the spirit of the urine, whilst the last contained more salt.

Van Helmont.

Van Helmont, after having commented a long time on this matter, concluded the *dueleck* to be an anomalous coagulum, arising from the salts of the urine, and an earthy volatile spirit, without any viscous or mucilaginous matter, and without any progressive induration, whilst the arthritic chalk, on the contrary, was the production of the induration of the synovia of the articulations, and the slow acidification of this viscid substance. On distilling this *dueleck*, by the dry way, he obtained a volatile alkaline spirit, a yellow crystallized mass deposited in the neck of the retort, a little empyreumatic oil, and a tasteless pulverizable coal.

Boyle found this calculus to be composed of oil and a <sup>Boyle's</sup> great quantity of volatile salt; Boerhaave supposed it to be a subtile earth, intimately united to volatile alkaline salts. Slare and Hales had observed nearly the same products as Van Helmont; but Hales, on distilling a calculus by a pneumatic apparatus, found, that it afforded 645 times it's volume (it weighed 230 grains) of an aeriform fluid, and that there only remained a residue, weighing 49 grains; hence he looked upon it to be similar to tartar, which likewise affords a considerable quantity of gas, and he concluded that the calculus was an animal tartar.

The decomposition of this substance was also attempted by other chemists, as Hoffmann, Pott, Geoffroy, Rutt, Hoffmann. Palucci, &c. But so little was the progress they had made in the investigation of this concretion, that any description would be unnecessary; a detail of their labours may be found in Haller.

Some physicians had likewise attempted to decompose it in the body, by various medicines, known by the name of lithontriptics. Amongst these were Alston, Whitt, Butter, and de Haen; they had made some experiments on the lithontriptic virtue of soap, of limewater, and of alkalies; the alkaline preparation known by the name of *fixed nitre* was particularly recommended by Vogel and Meckel; and the lithontriptic of Turin was understood to be the caustic soda or ley of the soap boilers; however, the more general opinion was at that time, that acids were the true dissolvents of this calculus, and that it contained a soluble earth, or an animal earth, perfectly analogous to that of bones. <sup>Attempts to decompose it in the body.</sup>

It was from the imperfection of the analysis of this substance, that the idea of it's being stony was entertained, till not many years ago; and although, as it appears, the experiments of Slare and Hales, as well as a few others, had before shown that these calculi commonly

Supposed  
to be calcareous.

consist of animal matter; this opinion was not generally received. As to the earth of which they were supposed to be composed, it is well known, the only distinction between earths, till about forty years ago, was into absolute and nonabsolute, and as the absolute earths were divided into the calcareous, magnesia, and clay, the calcareous was considered as that existing in urinary concretions, most probably from it's being so extensively diffused through the whole animal kingdom. With respect to it's being the earth of bones, the experiments of Margraaf proved the futility of the analogy.

Such were the ideas entertained of this substance before the experiments of Scheele; it was known that the matter of which it is composed exists more or less abundantly in urine, but the conjectures respecting it's nature were totally false, till this celebrated chemist proved it to be an acid, now known by the name of the lithic acid.

The experiments of Scheele were published in Sweden in the year 1776; and as Bergman had undertaken, much about the same time, an investigation of it, whose steps have been followed by several other chemists, some short account will be indispensable.

Distillation.

According to Scheele, this calculus afforded, on distillation, a volatile alkaline spirit, a brown sublimate, which became white on repeating the operation, and mixed with alkalis, gave no smell, but an acid taste, was soluble in boiling water and alcohol, did not precipitate lime from it's solution, and appeared to resemble, in some measure, the salt of amber; and there remained a black coal which preserved it's colour on red-hot iron. From 70 grains of calculus he obtained 28 grains of the sublimate, which is the concrete volatile lithic acid, and 12 grains of coal.

These experiments, it may be observed, resemble those

of Margraaff. From 1 ounce and a quarter of calculus, he obtained 2 drachms and a half of a sublimate, which, on rectification, afforded a little volatile alkaline spirit, and a white sublimate; but the fire being increased, a thick yellow acid oil. The white sublimate was for the most part soluble in water, and the evaporated solution deposited a triple salt, viz. a tasteless, a sweet, and a bitter one, each of which distilled with fixed vegetable alkali gave a little volatile alkali, the residuum appearing to him to show a trace of fusible salt of urine.

Hartenkeil obtained from one ounce of calculus 355 cubic inches of aerial matter, of which 301 were fixed air, and of the remainder one fourth was taken up by an equal quantity of nitrous air. He then got four drachms and nine grains of an empyreumatic oil, 55 grains of volatile alkaline spirit, and two drachms 33 grains of coal, which, on calcination, was nearly all consumed. Scopoli obtained from 25 grains of calculus the same number of cubic inches of fixed air.

Nicholas Tychsen, besides a little air, obtained a brown inflammable sublimate, dry volatile alkali, a little fluid resembling spirit of hartshorn, and a coal,  $\frac{1}{12}$  part of which was insoluble in muriatic acid.

Linke obtained in a strong distilling heat a yellow fluid like spirit of hartshorn, volatile alkali, a few drops of an empyreumatic oil, and a black shining coal; and Tittius got fixed air, volatile alkali, an empyreumatic oil, a brown sublimate, and a very black coal containing calcareous earth.

Frederic Hoffmann, Margraaff, and Hartenkeil, saw the calculus when exposed to the open fire, as well as Tychsen, before the blowpipe, become at first black, but afterwards with an evident volatile alkaline and empyreumatic smell, without any peculiar smoke, until it was consumed to a more or less trifling white or darkish residue.

Water.

From Scheele's experiments the calculus is perfectly soluble in water. Five ounces of boiling water dissolved eight grains. This solution changed the tincture of litmus to a red, did not precipitate lime from it's water, and on becoming cool, deposited the greatest part of the dissolved calculus in the form of fine crystals. Margraaf also found it soluble in water.

Frederic Hoffmann only obtained by boiling calculus in water a white turbid solution, which, on being exsiccated, left a whitish matter of a bitter saline taste, gave no empyreumatic alkaline smell on hot coals, as was the case with the calculus, and the remaining powder showed no trace of volatile alkali on levigation with potash and did not effervesce with vitriolic acid.

Bergmann likewise could not obtain a perfect solution of this calculus in boiling water, but observed some white spongy particles to separate, that were neither acted upon by water; alcohol, acids, nor caustic volatile alkali, and which exposed to the fire, afforded a coal difficult of incineration, the ashes of which were insoluble in nitrous acid; but he procured it in such small quantity as not to be able to examine it.

The experiments of Hartenkeil confirm those of Bergmann, who observed, that out of two drachms of calculus kept in six ounces of distilled water during four days, only two grains were dissolved, and only five by a boiling heat; whilst Tychem could dissolve none either in cold or boiling water; and Linke, who, on boiling the softened rind of calculus in 16 times it's quantity of water, found the small quantity dissolved to be only gelatinous.

Vitriolic  
acid.

Muriatic  
acid.

The vitriolic acid, according to Scheele, only dissolved the calculus when concentrated, and by the assistance of heat, during which operation he found the acid to arise in it's phlogisticated state. He found the muriatic acid had no effect upon it even at a boiling heat. Hales,



Margraaf, and Tychsen have observed, however, some slight degree of solution, according to the last, it communicated to this acid a bitter taste, when digested with it in a concentrated state; and Baillie met with one that was soluble in this acid at the common temperature of the air.

The same chemist informs us, that the nitrous acid attacked it even in the cold, that by the aid of heat it was entirely dissolved, sending forth red vapours. Margraaf, Hartenkeil, and Bergman, however, found a small residue, consisting of white spongy flocks, resembling those obtained by boiling in water. The solution was yellow.

If this process was performed in a retort, Scheele found, that the gas which arose precipitated limewater in the receiver; this proceeded from the fixed air, as Hales remarked, that a great quantity of it was always present in the calculus. The solution always tasted sour, even after saturation, although Bergman observed no smell of the nitrous acid; this showed the presence of a free acid. It coloured the skin, bones, glass, paper, after some time, of a beautiful red colour. If evaporated to concentration, it appeared as red as blood, but this colour disappeared on the addition of a few drops of nitrous acid, and was not to be recalled by alkalis or any other means. By a quicker evaporation, this high red liquor was converted into numberless bladders, and at last a dark red scum, which, on exsiccation, appeared of a black red, and which, on solution in water, gave it a beautiful rose colour, and was dissolved by all acids and caustic alkalis, with a loss of its colour, although it remained longer with the last. Exposed to the air, this dried red mass seemed inclined to deliquescence. The nitrous solution was not precipitated by the muriat of barytes, which would have been the case if it had contained the vitriolic acid, from which supposition the

calculus had been looked upon as of a gypseous nature; nor was it changed by metallic solutions; by the addition of a fixed alkali it's colour was only turned yellow, and when the alkali was abundant, the mixture, on digestion, became of a rose colour, which was immediately communicated to the skin; in this state it precipitated metals from their solutions, of different colours; the vitriol of iron black; vitriol of copper green; silver gray; corrosive muriatic of mercury, zinc, and lead, white. Limewater decomposed the nitrous solution, and produced a white precipitate, which precipitate, after having been welledulcorated and dried, was soluble in the nitrous and muriatic acids, without effervescence. This circumstance proves it could not be calcareous. Even after the supersaturation of these acids with the precipitate, the solution tasted sour, and inflamed on being evaporated to dryness; on calcining this precipitate in closed vessels, it left a spongy black matter resembling calcined alum; and in this state it effervesced with acids, and exposed to the blowpipe, was converted into quicklime. By the addition of oxalic acid, the nitrous solution was not affected either before or after it's mixture with alcalis, from which it appears that no calcareous earth was present in the calculus.

Bergman  
tries to find  
calcareous  
earth.

Bergman endeavoured to discover calcareous earth in this substance, by other means: first, he incinerated the coal of the calculus, and found that the white ashes effervesced a little with acids; that they formed gypsum with the vitriolic; that they were soluble in the nitrous even to  $\frac{1}{100}$ , and also a part, which he looked upon as calcareous, soluble in pure water. Secondly, by exsiccation of the nitrous solution of calculus, and incinerating the dried residuum, he obtained a calcareous powder. Thirdly, he observed that the vitriolic acid, on being mixed with the diluted nitrous solution, produced no change; but on

adding it to a strong nitrous solution, or to the diluted, when concentrated by evaporation, some small crystals were produced, which were soluble in distilled water, gave a precipitate with oxalic acid, and possessed all the properties of gypsum. Although these experiments prove beyond all doubt the existence of this earth in calculus, yet it exists in so inconsiderable a quantity, as rarely to exceed  $\frac{1}{200}$ ; and hence the cause that most chemists on the calcination of these substances find an extremely inconsiderable quantity of ashes. According to Pechlin, the nitrous acid which so forcibly dissolves the calculus when pure, possesses this property when dulcified with alcohol; Hartenkeil, however, found this menstruum so weak in its action, that six ounces of it only dissolved three grains of calculus.

Vinegar likewise dissolves calculus; thus Margraaf <sup>Vinegar.</sup> found, that one ounce of distilled vinegar took up one grain of it.

According to Tychsen, the citric acid is more active on <sup>Citric acid.</sup> this substance than distilled vinegar.

From Margraaf's experiments, the formic acid had <sup>Formic and phosphoric acids.</sup> very little, and the phosphoric no effect.

Lobb, by a continued digestion of calculus with the following substances, found it to be rendered partly more soft, and partly dissolved, viz. with lemon juice, vinegar, <sup>Lemon juice, &c.</sup> the expressed juices of radish, asparagus, sorrel, parsley, onions, oranges, mulberries, potatoes, pears, grapes and pumions; also with milk and different kinds of wine.

According to Scheele, 1000 grains of limewater dissolved, on digestion, 5,37 of calculus, which were again <sup>Lime water.</sup> precipitated by acids, at least in part.

This property of limewater had been before observed by Basil Valentine; but Hartenkeil and Tychsen found its action to be very small. It was this, however, which was so long recommended as a lithontriptic, particularly

by Robert Whytt; and the soap composed of the lime of all shell fish formed Stevens's celebrated medicine.

Alkalis.

Scheele found, that mild alkalis had no action upon calculis, but was dissolved by them in their caustic state, even in the cold. The solution in caustic potash was yellow, of a sweetish taste, did not render limewater turbid, was precipitated by all acids, even by the carbonic, and decomposed metallic solutions, viz. iron, of a brown colour; copper, gray; silver, black; and zinc, lead, and corrosive sublimate, white; if too much alkali was employed, it produced an ammoniacal odour; with respect to caustic volatile alkali, a large proportion was necessary for a solution.

Carbonated water.

It also appears, that water containing fixed air possesses a menstrual action on this substance. This was observed by Springsfeld, of the water at Karlsbad, and by Falconer, Saunders, and Percival, of water artificially impregnated; but with respect to the last it is so weak and insignificant as not to be esteemed better than common water in curing the disease.

Scheele and Bergman.

From their experiments, Scheele and Bergman have concluded, that the vesical calculus is an oily, concrete, volatile acid, united to a gelatinous part: that it's saline nature is proved by it's solubility in water; it's acidity, from the reddening of the tincture of litmus by this solution, and from it's union with alkaline salts, as well as with limewater, the caustic taste of which it moderates: that the difference between this acid and fixed air is known by it's not rendering limewater turbid; that it's inflammable nature is evident from the quantity of red vapours which arise during it's solution in the nitrous acid, and the red colour extricated from it by that acid. Finally, that it's volatility appears from the sublimate obtained by the distillation of the calculus. Scopoli and Titus have obtained the oxalic acid from this substance.

According to Morveau, the experiments of Scheele and Bergman present several important consequences. With respect to the composition of calculus, he alleges, that volatile alkali certainly forms a part of it, although the smallest, whilst the lithic acid composes the greatest. Scheele admits an animal gelatinous matter in it; and Morveau. Morveau concludes, that it contains an oil, or mucilaginous oil, capable of furnishing phlogiston; he grounds this assertion on the smoking vapours it gives with the nitrous acid; it however appears to this chemist, that it's quality perhaps cannot be ascertained by the coaly residuum found in the retort after distillation, for that the loss of  $\frac{3}{7}$  of the weight of the whole, verified by it's comparison with the sum of all the products, announces a decomposition of a considerable part of the acid, a portion of which converted into mephitic acid he thinks has produced with the phlogiston a real plumbago, which is detected by it's resistance to incineration.

From the nitrous solution not being rendered turbid by the oxalic acid, Scheele concluded, that not an atom of calcareous earth was present in the calculus, and this proof is looked upon as very correct by Bergman, although he acknowledges it may sometimes fail; as when the oxalic acid, instead of precipitating calcareous earth, forms with it a triple salt: he, however, found, as above mentioned, a very inconsiderable quantity in a calculus of the kidney. It may hence be seen how far they were erroneous who so long believed that the calculus of the bladder was a calcareous concretion, or at least of the nature of the earth of bones; and the inutility of their attempts to prevent it's formation, or to effect it's solution is now no longer surprising; Bergman having well observed, that every research for the cure of this disease ought to be founded on the perfect knowledge of the properties of the calculus itself. To conclude, it appears



Tennant.

from these experiments, that the calculi of the bladder are for the most part composed of this acid, called by Morveau, the lithic acid; that all which this last chemist has examined, and which have been very numerous, were found to be of the same nature, as well as those analyzed by Scheele and Bergman, although it may happen that a different species may be accidentally met with. Thus it appears from a letter to Morveau, written by Tennant, of the Royal Society of London, that in his experiments on the vesical calculi, he found some that only lost, on calcination,  $\frac{2}{3}$  of their weight; that the residuum, forming a transparent glass, on cooling became white. To judge of them by these facts, they ought, according to Morveau, to contain a pretty considerable quantity of phosphat of lime, with a superabundance of acid.

Scheele found, that more or less calculous matter was present in all urine, even in that of infants; that the brick-coloured deposit to be seen in the urine of patients under fever was of the same nature, that it separated by cooling alone, and that it might be redissolved by the assistance of a sufficient degree of heat.

Fourcroy.

After Bergman and Scheele had investigated the nature of the calculous matter; the next author of any consequence was Fourcroy; he examined a great number of varieties, and the result of his analysis is as follows:

1. The aqueous solution of calculi reddened the dyed paper of turnsole.

2. By distillation on the fire, and by the action of the nitric acid, they afford prussic acid. At first there arises a colourless liquor, then some elastic fluids, composed of carbonic acid, of hydrogen gas, and a little azot. In the neck of the retort he found some brilliant, lamellated, and more or less yellow crystals of pure lithic acid, and a small quantity of carbonat of ammonia; there remained in the retort a great quantity of coal; he obtained no

oil. On examining the liquid product, the odour of free prussic acid was to be recognized. In the water a small quantity of carbonat of ammonia and prussiat of ammonia were found. The presence of the prussic acid was easily distinguished by the oxyd of iron newly precipitated, which was converted into Prussian blue on casting it into this liquor.

3. From these facts Fourcroy concludes, that the vesical calculus contains but a very small portion of hydrogen, as a very little ammonia is formed; that a great quantity of azot is disengaged, but no oil; that the lithic acid contains but a very small quantity of oxygen, very little of the prussic and carbonic acids being formed; and besides, from there remaining in the retort a very large quantity of coal.

4. From these observations he likewise infers, that the prussic acid contains more oxygen than the lithic acid, since there is only very little prussic acid formed from the decomposition of a great quantity of lithic acid; that probably carbonic acid is formed at the same time, but in small quantity in comparison to the mass of coal remaining in the retort.

This chemist admits that these general considerations are not sufficient to explain the phenomena which the analysis of the vesical calculi present; he has therefore added a detail of his experiments made in 1787, which, although they are far from rendering the subject complete, may throw further light on their decomposition.

These were made upon four kinds of calculi, and show a great analogy to those of Scheele, published a few years before. All his truths are here attested; the presence likewise of some atoms of lime, indicated by Bergman, are to be found in them; that of the phosphat of ammonia, which pretty constantly exists in these calculi, and of

the phosphat of soda, which is often to be seen crystallized between the strata of the calculi. He has likewise recognized in these experiments the volatility of the lithic acid, it's greater solubility in warm than in cold water, and it's being capable of crystallization by means of cold; he likewise found, that the calculus spontaneously gives the prussic acid by distillation. The result of the labours of this chemist are, that the only appearance of lithontriptics is in the use of caustic fixed alkalis, &c. With respect to the vesical calculi of other animals, nothing had been done respecting their investigation until this chemist made a few experiments upon two; one taken from the horse, the other from an ox, but neither of them afforded any thing analogous to the lithic acid; the products he obtained were the carbonat and phosphat of lime.

Dr. Wollaston.

The vesical calculi examined by Dr. Wollaston are the following, viz.

Experiments on the fusible calculus.

*Fusible calculus.* This was first ascertained to differ from that of Scheele, by Tennant, who found, as before observed, that instead of being nearly consumed by the blowpipe, a large proportion of it was left fused into an opaque white glass, which he conjectured to be phosphorated lime united with other phosphoric salts of the urine; but he never attempted a more minute analysis. Stones of this kind, according to Dr. Wollaston, are always whiter than those described by Scheele, and some specimens are perfectly white. The greater part have an appearance of sparkling crystals, which are most discernible where two crusts of a laminated stone have been separated from each other. Having had an opportunity of procuring these crystals alone, voided in the form of a white sand, he was enabled to determine the nature of the compound stone, in which they are cemented by other ingredients.

The crystals consist of phosphoric acid, magnesia, and volatile alkali; the stone contains also phosphorated lime and generally some lithic acid. The form of the crystal is a short trilateral prism, having one angle a right angle, and the other two equal, terminated by a pyramid of three or six sides. On submitting them to experiment he found, that,

1. Heat drives off the volatile alkali from the crystals, and they are rendered opaque, or may be partially fused. The phosphorated magnesia may then be dissolved in nitrous acid, and by addition of quicksilver, dissolved in the same acid, a precipitate of phosphorated quicksilver is obtained, from which the quicksilver may be expelled by heat, and the acid procured separate. By addition of vitriolic acid to the remaining solution, Epsom salt is formed, and may be crystallized after the requisite evaporation of the nitrous acid, and separation of any redundant quicksilver.

2. These crystals require a very large quantity of water for their solution, but are readily soluble in most, if not all acids, viz. vitriolic, nitrous, marine, phosphoric, saccharine, and acetous; and when precipitated from them reassume the crystalline form.

3. From the solution in marine acid, sal ammoniac may be obtained by sublimation.

4. Although the analysis is satisfactory, the synthetic proof is, if possible, still more so. After dissolving magnesia in phosphoric acid, the addition of volatile alkali immediately forms the crystalline precipitate, having the same figure and properties as the original crystals.

5. If volatile alkali be cautiously mixed with recent urine, the same compound will be formed; the first appearance that takes place when a sufficient quantity of alkali has been gradually added, is a precipitate of these triple crystals. These constitute the greater part of the

fusible stone, so that a previous acquaintance with their properties is necessary, in order to comprehend justly the nature of the compound stone in which they are contained.

The most direct analysis of the compound stone is effected by the successive action of distilled vinegar, marine acid, and caustic vegetable alkali.

6. Distilled vinegar acts but slowly upon the calculus when entire; but when powdered, it immediately dissolves the triple crystals, which may be again precipitated from it as crystals by volatile alkali; and if the solution has not been aided by heat, scarcely any of the phosphorated lime will be found blended with them.

In one trial the triple crystals exceeded  $\frac{1}{10}$  of the quantity employed; but it seemed unnecessary to determine the exact proportion which they bear to the other ingredients in any one instance, as that proportion must vary in different specimens of such an assemblage of substances not chemically combined.

Marine acid poured on the remainder dissolves the phosphorated lime, leaving a very small residuum.

This is soluble in caustic vegetable alkali entirely, and has every other property of mere lithic acid.

The presence of volatile alkali in the compound stone may be shown in various ways.

7. In the distillation of this stone, there arises first volatile alkali in great abundance, a little fetid oil, and lithic acid. There remains a large proportion charred. Water poured upon the remaining coal dissolves an extremely small quantity of a salt, apparently common salt, but too minute for accurate examination. Distilled vinegar dissolves no part of it, even when powdered. Marine acid dissolves the phosphorated lime and phosphorated magnesia, leaving nothing but a little charcoal. From this solution, vitriolic acid occasions a precipitate



of felenite, after which triple crystals may be formed by addition of volatile alkali.

8. Marine acid also acts readily upon a fragment of the stone, leaving only yellowish laminæ of lithic acid. When the solution has been evaporated to dryness, sal ammoniac may be sublimed from it; and the two phosphorated earths are found combined with more or less of marine acid, according to the degree of heat employed. If the proportion of the earth is wished to be ascertained, acid of fugar will separate them most effectually, by dissolving the phosphorated magnesia, and forming an insoluble compound with the lime.

9. Caustic vegetable alkali has but little effect upon the entire stone, but if heated upon the stone in powder, a strong effervescence takes place from the escape of alkaline air, and the menstruum is found to contain lithic acid precipitable by any other acid. Some phosphoric acid also, from a partial decomposition of the triple crystals, is detected by nitrated quicksilver.

10. The triple crystals alone are scarcely fusible under the blow-pipe; phosphorated lime proves still more refractory; but mixtures of the two are extremely fusible, which explains the fusibility of the calculus.

The appearance of the lithic strata, and the small proportion they bear to the other ingredients, show that they are not an essential part, but an accidental deposit, that would be formed on any extraneous substance in the bladder, and which probably in this instance concretes during any temporary interval that may occur in the formation of the crystals.

*Mulberry calculus.* This stone, though by no means overlooked, and though pointed out as different from other species, has not, according to Dr. Wollaston, been subjected to any farther analysis than is given by Dr.

*Mulberry  
calculus.*

Dawson, (2d vol. Med. Transf.) who found that his lixivium had little or no effect upon it; and by Lane, (Phil. Transf.) who, among other simple and compound stones, gives an account of the comparative effects of lixivium and heat upon a few specimens of mulberry calculus, viz. (No. 7, 8, 9, 10;) but neither of these writers attempted to ascertain the constituent parts.

Though the name has been confined to such stones as, from their irregular knotted surface and dark colour, bear a distant resemblance to that fruit, Dr. Wollaston has found the species, chemically considered, to be more extensive, comprehending some of the smoothest stones to be met with, one of which in his possession is of a much lighter colour, so as to resemble in hue, as well as in smoothness, the surface of a hemp-seed. From this circumstance it appears probable to this chemist, that the darkness of irregular stones may have arisen from blood voided in consequence of their roughness.

The smooth calculus was found to consist of lime united with the acids of sugar and of phosphorus. The rougher specimens have generally more lithic acid in their interstices.

1. Caustic vegetable alkali acquires a slight tinge from a fragment of this kind of stone, but will not dissolve it. When powdered it is thereby purified from any quantity of lithic acid that it may contain. Phosphoric acid will then dissolve the phosphorated lime, and the remainder, after being washed, may be decomposed by the vitriolic. The affinity of this acid, for a certain proportion of lime, is superior even to that of acid of sugar; selenite is formed, and the acid of sugar may be crystallized, and by the form of its crystals recognized, as well as by every other property. It is easily soluble, occasions a precipitate from lime water, and from a solution of selenite, and

with mineral alkali forms a salt that requires a large quantity of water for it's solution.

2. When the stone has been finely powdered; marine acid will slowly dissolve all but any small quantity of lithic matter which it may contain. After the solution has been evaporated to dryness, no part is then soluble in water, the marine acid being wholly expelled. When the dried mass is distilled with a greater heat, the saccharine acid is decomposed, and a sublimate formed, still acid and still crystallizable, but much less soluble in water, and which does not precipitate lime from limewater. After distillation, the remainder contains phosphorated lime, pure lime and charcoal, and when calcined in the open air, the charcoal is consumed and the whole reduced to a white powder. The two former may be dissolved in marine acid, which, when evaporated to dryness, will be retained only by the lime; so that water will then separate the muriated lime, and the phosphorated may afterwards be submitted to the usual analysis.

*Bone earth calculus.* Besides that of Scheele, and the two already noticed, there is, according to Dr. Wollaston, also a fourth species of calculus occasionally formed in the bladder, distinct in it's appearance, and differing in it's component parts from the rest, for it consists entirely of phosphorated lime. It's surface is generally of a pale brown, and so smooth as to appear polished; when sawed through, it is formed very regularly, laminated, and the laminæ in general adhere so slightly to each other as to separate with ease into concentric crusts. In a specimen from Dr. Baillie, each lamina is situated in a direction perpendicular to the surface, as from an assemblage of crystallized fibres.

Bone earth  
calculus.

This calculus dissolves entirely, though slowly, in marine or nitrous acid, and, consisting of the same elements

as earth of bones, may undergo a similar analysis, unnecessary to particularize.

By the blowpipe it is immediately discovered to differ from other urinary calculi; it is at first slightly changed, but soon becomes perfectly white, still retaining it's form till urged with the utmost heat from a common blowpipe, when it may at length be completely fused. But even this degree of fusibility is superior to that of bones. The difference consists in an excess of calcareous earth contained in bones, which renders them less fusible. This redundant proportion of lime in bones renders them also more readily soluble in marine acid, and may, by evaporation of such a solution, be separated, as in the last experiment upon mulberry calculus. The remaining phosphorated lime may be redissolved by a fresh addition of marine acid, and being now freed from redundant lime, will, upon evaporation of the marine acid, assume a crystalline form. As the laminated calculus contains no excess of lime that will at once yield such crystals, their appearance is described in the account of the calculus of the prostate gland, by this chemist, and in the first experiment.

Lithor-  
triptics.

With respect to the remedies for this disease, Dr. Wollaston is of opinion, that when a calculus is discovered by the evacuations to be of the fusible kind, there appears a more favourable prospect of relief than with respect to the mulberry calculus; for any acid that is carried to the bladder will act upon the triple crystals, and most acids will also dissolve the phosphorated lime, whilst alkalis, on the contrary, would rather have a tendency to add to the disease. Besides this species, the fusible calculus has afforded decisive marks of it's presence in the case which furnished this chemist with his specimen of triple crystals, and by the description given by Forbes (in his



Treatise upon Gravel and Gout, ed. 1793. p. 65.) of a white crytallized precipitate, no doubt is entertained that his patient laboured under that variety of the disease.

With respect to the mulberry calculus, it appears, that an intimate knowledge of it's properties will leave but finall prospect of relief from any solvent; but by tracing the source of the disease some hopes may be entertained of preventing it. As the saccharine acid is known to be a natural product of a species of oxalis, it seems more probable that it is contained in some other vegetables, or their fruits taken as aliment, than produced by the digestive powers, or secreted by any diseased action of the kidneys. The nutriment would therefore become a subject of minute inquiry, rather than any supposed defect of assimilation or secretion.

As to the bone earth calculus, although so nearly allied to that of the *prostate*, it is still manifestly different, and cannot be supposed to originate from that source; but if ever the drinking of water impregnated with calcareous earth gave rise to stone in the bladder, Dr. Wollaston thinks, that this would most probably be the kind generated, and that the remedy must evidently be of an acid nature.

Although from want of sufficient attention to the varieties of sediment from urine, and want of information with regard to the diversity of urinary calculi, the deposits peculiar to each secretion are yet unknown; it seems probable to this chemist, that no long course of observation would be necessary to ascertain with what species any individual may be afflicted.

The lithic, which is by far the most prevalent, fortunately affords great variety of proofs of it's presence. Particles of red sand (as they are called) are it's crystals. Fragments also of larger masses and small stones are frequently passed, and it is probable that the majority of ap-



pearances in the urine, called purulent, are either the acid itself precipitated too quickly to crystallize, or a neutral compound of that acid with one of the fixed alcalis.

Dr. Pearson. The experiments and observations which Dr. Pearson has made on this subject, are principally on a substance which he has found to be very generally a constituent part of both urinary and arthritic concretions. This substance is obtained by dissolving it out of these concretions, by lye of caustic fixed alkali, and precipitating it from the solution by acids. This was the method by which Scheele separated it; but according to Dr. Pearson, he did not consider its importance, nor of course investigate its properties; he even does not seem to have been aware of its being a distinct constituent part of the urinary concretion, for when he relates the experiments of precipitating matter from the nitric solution of calculus by metallic salts, no distinction is made between the precipitations in this experiment and that in the former, yet Dr. Pearson shows, that in the one case the precipitate is a peculiar animal oxyd, and in the other they are metallic phosphates.

As Scheele obtained an acid sublimate, it has been imagined by some writers, that the precipitate by any acid (even by the carbonic) from the alkaline menstruum was an acid, the same as that obtained by sublimation, and which, in the new system of chemistry, has been denominated *lithic acid*; but the experiments of Dr. Pearson show that these substances are different species of matter.

The calculi he made use of were of two sorts: the one was white, smooth, and lamellated; the other of a nut-brown colour, with an uneven surface; both were roundish, and the powder of both mixed together.

Discovers a  
peculiar  
animal

The precipitate obtained by the solution of this powder in lye of caustic soda, and the addition of diluted sul-

phuric acid to saturate the alkali, when washed and dried, was a mass of very light, whitish crystal, resembling mica, and after having been submitted to examination by chemical means, afforded the following conclusions as the most obvious.

1. It appears that at least one half of the matter of the urinary concretions united to caustic soda, &c. is precipitated from it by acids.

2. This precipitate does not indicate acidity to the most delicate tests; and as it is inodorous, tasteless, and scarcely soluble in cold water, does not unite to the alkali of carbonate of potash, of soda, or of ammonia, nor to oxyd of mercury, nor to the lime of lime water, nor decompose soaps, or prussiate of iron; and as its combination with caustic soda resembles soap, more than any other double salt known to consist of an acid and alkali, this precipitate does not belong to the genus *acid*.

3. As this precipitate could not be sublimed, without being decomposed, like animal matter, and also for the above reason, it cannot be the same thing as the *acid sublimate* of Scheele, or the succinic acid.

4. As it does not appear to be precipitable, nor form a viscid solution with water, it cannot be referred to the *animal mucilages*.

5. On account of its manner of burning in the air under the blow-pipe, and its yielding, on exposure to fire in close vessels, the distinguishing products of animal matter, (especially ammonia and prussic acid) as well as on account of its affording a soap-like matter with caustic soda, Dr. Pearson considers this precipitate as a species of animal matter; and from its composition being analogous to that of the substances called in the new chemistry *animal oxyds*, that it belongs to this genus. Its peculiar and specific distinguishing properties are

*imputrescibility; facility of crystallization, insolubility in cold water, and that most remarkable property of all others, producing a pink or red matter, on evaporation of it's solution in nitric acid.*

Having found this precipitate to be an oxyd, and not, as commonly supposed, an acid, this chemist thought it probable, that, like other analogous oxyds, it was *acidifiable*; but after making the attempt to effect this by means of the oxymuriatic, the nitro-muriatic, and the nitric acid, which are capable of acidifying similar oxyds, his hopes of acidifying this animal oxyd were exploded: he was however indebted to that pursuit for the curious discovery of the change of this most common basis of urinary concretions (the animal oxyd) into ammonia and carbonic acid, by the oxygen of the above acids, which will be found extremely important in the explication of several phenomena. For it now appears, according to this chemist, that the inflammation on evaporation of the nitric solution of this animal oxyd, arose from the nitrat of amonia, the *nitrum flammans* of the old chemists, compounded in the experiment. This inflammation also sometimes takes place, on evaporation of nitric solutions, both of urinary concretions, and of urine itself evaporated to the state of soft extract, on account of the ammonia already existing in the substances. The composition of ammonia also explains the disappearance of the whole matter of some sorts of urinary concretions, a very small residue of black matter excepted, by repeated affusion and evaporation of nitric acid, from the solution of them in this menstruum.

With respect to the matter which remained on the strainer, after the filtration of the solution of the powdered calculus in the lye of caustic soda, it was on being dried an impalpable white, tasteless, heavy powder, and on being submitted to experiment, appeared to consist of

phosphat of lime ; accordingly three hundred grains of urinary concretions examined by Dr. Pearson appear to have contained of

	Grains
Peculiar animal oxyd .....	175
phosphat of lime .....	96
ammonia (and most probably phosphoric acid united to the ammonia) water, and common mucilage of urine, not collected and weighed, by estimation .....	29

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300

The next object of this chemist was to obtain the acid sublimate of Scheele, or lithic acid, as it has been called, and to compare it with the before mentioned animal oxyd.

Having taken 100 grains of an urinary concretion which had been previously found to contain principally the above animal oxyd, they were exposed in a tube for that purpose to the fire, first to a low temperature, and gradually to a very elevated one; by which means, besides a gas amounting to 24 oz., which consisted of nearly 16 of carbonic acid gas, and air with a larger proportion of nitrogen gas than is found in atmospheric air, an offensive smell of empyreumatic animal oil mixed with that of prussic acid, 20 grains of a brown sublimate of carbonat of ammonia and a residue of 30 grains of an almost pure carbon, with 10 grains of heavy black and brown matter, in which were many small white spiculæ, a dark gray matter was obtained which weighed 15 grains. It had been raised about half an inch above the carbonaceous residue. This sublimed gray matter on examination was found not to contain any ammonia, nor throw down any prussiat of iron with sulphat of iron. It reddened turnsole paper and tincture. It was soluble in caustic soda, from which solution muriatic acid gave no

precipitate, for although on dropping it into the solution, a milkiness appeared, the liquid soon grew clear again.

Ten grains of this sublimate dissolved in four ounces of boiling water, and on evaporation to half an ounce, a copious deposit took place, on cooling, of white spiculæ, which Dr. Pearson thinks, are analogous to benzoic acid. The sublimate had a sharp, but not sour taste. Being boiled in muriatic and nitric acids, no solution took place, and what is more particularly to be observed is, that it left no red or pink matter on evaporating the nitric acid from it. The sulphuric acid only dissolved by the aid of heat, without effervescence, from which nothing was precipitated by caustic soda; on evaporating the solution to dryness, black fumes arose, leaving behind only a black stain. This sublimed matter did not render limewater turbid. Boiled in muriatic acid, so as to carry off all but a very little free acid; on the addition of limewater, there was no turbid appearance, but milkiness ensued on adding oxalic acid. The whole of this sublimate, with the spiculæ, in the ten grains before mentioned, which appeared to be of the same nature, amounted by estimation to 18 grains; and Dr. Pearson looks upon this to be the acid sublimate of Scheele.

This experiment was repeated a fourth time, and affords evidence, according to this chemist, of the wide difference between the animal oxyd and the acid sublimate of Scheele.

If this conclusion be allowed to be just, it will be necessary to give a name to this urinary animal oxyd. Agreeably to the principles of the new chemical nomenclature, the name should be lithic oxyd. But the term lithic this chemist conceives to be a gross solecism, and he prefers the name of *ouric or uric oxyd*; and although it's existence in arthritic as well as in urinary concretions may be an objection, still from it's being found in greater



abundance by far in the urinary passages than in other situations, and therefore falling under common observation as an ingredient in the urine, philology may allow it's admiffion.

The preceding facts and experiments are applicable to a variety of ufes in chemical investigation; fince we are now not only able to detect in the eafieft manner the *prefence* of the minuteft proportion of the above animal oxyd in urinary concretions, and alfo in other fubftances, but even to determine it's *proportion* to the other conftituent parts, in the fpace of a few minutes, in moft cafes, and in all in a very little time; without any other apparatus than nitric acid, a round bottomed matrafs or glafs difh, and a lamp; by which method Dr. Pearfon has examined above 300 fpecimens of concretions of the human fubject and other animals, principally urinary, and alfo many other from other parts, particularly thofe from the joints, and he found,

1. That out of 200 fpecimens of urinary calculi, not more than fix did not contain the animal oxyd, *i. e.* about 32 out of 33 contained it.

2. That the proportion of this oxyd was very different, varying from  $\frac{1}{200}$  (exclufive of water) to  $\frac{1}{2}\%$ ; but for the moft part, varying between  $\frac{8}{200}\%$  and  $\frac{14}{200}\%$ , for in fome the interior part contained this oxyd, and the exterior part not, whilft in others on the contrary, the exterior did, and the interior did not.

3. That the common animal mucilage of urine is frequently found in concretions, in very different proportions, but is, perhaps, never a principal conftituent part of them.

4. That the animal oxyd was not prefent in the urinary or any other concretions of any animal but the human kind.

5. That this animal oxyd is present also in human arthritic calculi, but not in those of the teeth, stomach, intestines, lungs, brains, &c.

From these experiments on the acid sublimate, it appears very doubtful to this chemist, whether the *lithic acid* of Scheele exists as a constituent of urinary concretions, or is compounded in consequence of a new arrangement taking place of the elementary matters of the concretion, by the agency of fire; but it is demonstrated, that the urinary animal oxyd is really a constituent part, and even a principal one, of almost all human urinary calculi.

Beside the analysis of the human calculus, we are indebted to the same ingenious chemist for some experiments and observations on the urinary calculi of the dog, the rabbit, and the horse.

Calculus of  
the dog.

1. *Urinary calculus of the dog.* This calculus may be looked upon as a great curiosity, being, perhaps, the only specimen in London. The animal was in perfect health, and dissected by H. Leigh Thomas.

It's surface is oval,  $3\frac{3}{4}$  inches in length, and three in breadth, white as chalk, and rough and uneven on it's surface. No nucleus was found on being sawed through, it was not laminated, but near the centre radiated, and it contained shining *spicula*. In the other parts it was generally compact and uniform in it's texture. It weighed nearly 10 ounces and a half. It's specific gravity was greater than that of human urinary concretions in general, which this chemist has learned to be the case from experience, with respect to the urinary and intestinal concretions of other brute animals, especially those of the horse.

The specific gravity of the present calculus was 1,7.

That of a human urinary calculus called mulberry cal-

culus, which consisted almost entirely of uric oxyd, was 1,609, and that of another of the same composition, but quite smooth, and extracted by Ford, was 1,571.

1. The present calculus of the dog had no taste, nor smell, till exposed to the fire.

2. Exposed to the blowpipe it first became black, and emitted the smell of common animal matter; it next smelled strongly of empyreumatic *liquor cornu cervi*, and after burning some time, became inodorous and white, and readily melted, like superphosphat of lime.

3. Triturated with lye of caustic soda, there was a copious discharge of ammonia.

4. It formed a clear and colourless solution, on boiling in nitrous acid, and evaporated to dryness left a residue of *white bitter matter*, which emitted a weak smell of animal matter under the blowpipe.

5. A mixture of 150 grains of the powdered calculus, and 2 pints and a half of pure water, being distilled to three ounces, the liquor contained only a little ammonia. The three ounces of residuary liquor being filtered and evaporated, gave 20 grains of phosphat of ammonia, with a little animal matter, and the residuary undissolved matter amounted to 67 grains.

6. These 67 grains being triturated with four ounces of caustic soda lye, discharged very little ammonia. They likewise afforded phosphat of lime and animal matter.

7. This residuary insoluble substance in caustic lye, under the blowpipe, first turned black, and then grew white, but could not be melted.

These experiments demonstrate, that the above concretion contained none of the uric oxyd, but was composed, principally at least, of phosphats of lime and ammonia, and animal matter.

The present instance leads this chemist to explain the

reason of the fusibility of calculi. The above experiments prove it to depend on the discharge and decomposition of the ammonia of the phosphat of ammonia, during the burning away of the animal matter; hence the residuary phosphoric acid readily fuses, and uniting to the phosphat of lime, composes superphosphat of lime, a very fusible substance. The phosphat of ammonia being dissolved by water, or caustic alkaline lye, the remaining matter is infusible, being phosphat of lime.

A very hard, brittle, and blackish intestinal calculus of a dog, was found to be of greater specific gravity than human urinary calculi, and to have the same composition as that of the dog above described.

This also was found to be the composition of a white, smooth, round, intestinal calculus of a horse, the specific gravity of which was 1,791.

Calculus of  
a rabbit.

2. *Urinary calculus of a rabbit.* Dr. Pearson likewise looks upon this as a curiosity, being the only instance he has seen. The animal from which it was taken was very fat and healthy.

It's form was spherical, and of the size of a small nutmeg. It's colour a dark brown, it's surface smooth, and it's consistence hard, brittle and heavy. When broken, it appeared to consist of concentric laminæ. It's specific gravity was 2. It consisted principally of carbonat of lime and common animal matter, with, perhaps, a very small proportion of phosphoric acid, but contained no uric oxyd.

Calculus of  
the horse.

3. *Urinary calculus of the horse.* This chemist has examined several specimens in cabinets, said to be vesical calculi of this quadruped, and he found none of them to contain the uric oxyd, but that they consisted (as well as the calculi from the stomach and intestines of the same animal) of phosphat of lime, phosphat of ammonia, and

common animal matter, which melted like superphosphat of lime, after burning away the animal matter and ammonia.

This concretion, given by Dr. Baillie, was of a blackish colour, very hard and brittle in its consistence, and without smell or taste. It felt heavier than human urinary calculi. From the experiments of this chemist, it appears, that like the former calculus from a rabbit, it consisted of carbonat of lime, and common animal matter.

A renal calculus of a horse, in Heavyside's collection, appeared, on examination, to consist of carbonat of lime and common animal matter. Another specimen of the same sort consisted of phosphats of lime and ammonia, and common animal matter. It fused under the blow-pipe. A vesical calculus was composed of the same ingredients.

Dr. Pearson has met with two instances of a deposit of a prodigious quantity of matter in the urinary bladder of horses, which had not crystallized, or even concremented; it amounted in one specimen given to him by Dr. Marshall, to several pounds weight, and in the other, which is in the possession of Home, to about 45 pounds. Its composition was principally carbonat of lime and common animal matter.

Such deposits, it appears, are not unfrequent.

This chemist has not found any instance of human urinary calculi of similar composition to that of the rabbit, and those of horses, above described, which consist of carbonat of lime and animal matter; and he is of opinion, that they very rarely occur of a similar composition to those of the dog and horses, which were found to consist of phosphat of ammonia, phosphat of lime and animal matter, without containing *uric oxyd*.



The difference in the constitution of urinary concretions may depend on the difference of the urinary organs of different animals, on the food and drink, and on the various diseased and healthy states of the urinary organs.

Dr. Pearson has not found the uric oxyd in the urinary concretions of any phytivorous animal; but whether it be formed in the human animal, when nourished merely by animal matter, must be determined by future observations. He found the stomach concretion, called *oriental bezoar*, to consist merely of vegetable matter, as did the intestinal concretion of a sheep.

**Brugnatelli.** Brugnatelli, upon submitting different kinds of calculi to chemical experiment, found,

1st. That all, as several chemists had observed, were in part soluble in water, when cast into it in a pulverized state at the boiling point. The filtered solution, whilst warm, was of a yellow colour. The portion that remained on the filter was not entirely soluble in fresh water.

2d. That the part soluble in water was the acidulous phosphat of lime, which he found to exist in the greatest number of *white calculi*.

Brugnatelli seems surpris'd that Scheele and Bergman, and other chemists who have examined this substance, should have looked upon the soluble part to be the lithic acid, and that Scheele should maintain that these calculi contained no lime.

Fourcroy, however, supports the fact, that this matter, soluble in water, is the lithic acid, and he never met with the acidulous phosphat of lime in the concretions, except in one; it is the lithic acid which always, in the solution, reddens litmus.

3d. That the portion of the vesical calculus, which was not dissolved by the water, contains a substance abounding

in the oxalic radical. As a proof of this, he poured some concentrated nitric acid on the insoluble residuum, which it dissolved with a little effervescence, and a disengagement of very thick, red, nitrous vapours. There was no residuum. The solution was of a yellow colour, and stained the skin of a rose colour, which disappeared on touching it with the nitric acid. On pouring into this solution some oxalic acid, there was no vestige of the presence of lime. There was no turbidness. Brugnatelli, however, did not conclude from this, that there was none of this earth, having found lime to exist in saline combinations, without being indicated by the oxalic acid.

He had besides observed, that calculi and sediments of urine, when treated with the nitric acid, afforded oxalic acid, from which he contended, that the lime was in a state of oxalat, already saturated, and taken again into solution by the nitric acid. In such a case the oxalic acid was no longer capable of acting on the lime.

4th. That a great part of the calculus, soluble in the nitric acid, is converted into oxalic acid. As a proof of this, a certain quantity of the solution of the residuum of the calculus in nitric acid was evaporated until the entire disappearance of the nitric acid, and afterwards tried with lime water, a deposit formed as if it had been with the solution of pure oxalic acid.

He also dissolved the residuum of three different calculi in concentrated nitric acid, and gradually distilled the three solutions; after a sufficient concentration, they were placed in a cool place. The next day he found in one of them some beautiful crystals of oxalic acid, with a portion of thick liquor, from which he could not extract any more crystals. The other two gave no appearance of crystallization, although the liquors contained a great deal of the oxalic acid in a combined state.

He decomposed, by the means of ammonia, another

another portion of the calculous solution by the nitric acid, and obtained a crystallized precipitate somewhat transparent. This when dried was of a shining white colour, composed of small lamellated crystals. It's flavour was rather sharp, and it reddened the tincture of litmus. This crystalline mass easily dissolved in the nitric acid, of which it deepened the colour; in distilled water, it formed a turbid solution that became clear on repose, and deposited a little white matter resembling lime. This solution had scarcely any distinct flavour. The oxalic acid did not render it turbid, but produced a very abundant precipitate in the lime water, which was the oxalat of lime.

The crystals separated by the ammonia from the nitrous solution of the calculus, appear according to Dr. Brugnatelli to be the acidulous oxalat of lime. Distilled water separated the free acid. He neither met with the oxalic nor the prussic acid in the calculi he has analyzed. The saline precipitate, separated from the calculous solution in the nitric acid by ammonia, appears to deserve to be better examined.

Fourcroy  
and Vau-  
quelin.

Fourcroy and Vauquelin, instead of finding urinary calculi constantly or totally formed of uric acid (lithic acid) as Scheele had announced, or phosphat of lime mixed with this acid, according to Hartenkeil and Pearson, have discovered from their numerous experiments, besides the uric acid and phosphat of lime, five other constituent parts which were unknown before to exist in human urinary calculi, viz. ammonia, ammoniaco-magnesian phosphat, oxalat of lime, silex, and an animal matter.

Discover 5  
new substan-  
ces in cal-  
culi.

The aspect of the calculus alone is almost always sufficient to indicate the nature of it's mass, when it is formed of only one substance, or of the different strata of which it is composed. If the appearance alone be

not sufficient to give an exact notion of it's nature, or that of it's strata, it is readily known by means of a few small chemical trials to be related. The chemical characters of each of these substances are so well laid down by these two chemists, as to make it impossible almost to be mistaken in them, at the same time it gives rise to a new classification of calculi, according to their component parts.

*Uric acid*, for an account of which vide lithic acid, Uric acid.  
art. acids.

*Urat of ammonia*. This is more rare in calculi than Urat of am-  
the uric acid ; it is found in thin strata of a texture but monia.  
little crystallized, easily rubbed down, of a colour resembling coffee with milk, very rarely alone, often mixed with uric acid, or with phosphats interposed between their strata, easily known by it's rapid solubility in the lye of caustic potash, during which there is an extrication of ammonia, whilst pure uric acid affords none.

*Phosphat of lime*. This is found of a white colour, Phosphat of  
rough, granular, friable, or in very brittle white strata, lime.  
marking the hands, paper or stuffs, like chalk, breaking on being sawed, insipid to the taste, insoluble in water ; soluble in nitric, muriatic, and even in the acetous acid, forming acid solutions, precipitated by ammonia and the alkalis, especially by the oxalic acid. It forms white, friable, earthlike calculi, or the calculous strata of that nature. It is never alone in calculi ; it is intimately mixed with a gelatinous animal matter, which remains in the form of a membrane, when suspended in weak acids so as to dissolve the saline part ; it is this animal matter that produces the coal obtained in the calcination of these species of white friable calculi, and the fatuous odour of glue when they are boiled in water. These species of calculi are easily dissolved in the bladder by muriatic acid, so much diluted as scarcely to be sapid.

Phosphat of  
ammonia-  
co-magne-

*Phosphat of ammoniaco-magnesia.* This is white, and semitransparent, lamellated, with spathic strata sometimes crystallized in prisms or in the form of cock's combs on the calculi, of a faint sweetish savour, resembling gypseous alabaster, more soluble in water than the preceding substance, very soluble in the weakest acids, decomposed by fixed alkali, which disengages the ammonia and precipitates the magnesia. It never forms urinary calculi of itself; it is often mixed with phosphat of lime, always in the white friable calculi; sometimes it covers of itself a nucleus of uric acid, or oxalat of lime. The same animal gelatinous matter is found in it as in the preceding. It is of all calculous matter the most soluble, by an injection of extremely weak and diluted muriatic acid into the bladder.

Oxalat of  
lime.

*Oxalat of lime.* These chemists found it forming the solid basis of the *mulberry* calculi, so called from the inequality of their surface, and their blackish brown colour. This salt is combined in them with an animal matter the most abundant of all that exist in calculi; this combination is very dense, difficult to saw, taking the form of caps placed upon each other, which give rise to projecting tubercula, as it were deposited on a common centre; receiving a polish like that of ivory; diffusing a fatuous and spermatic odour on being cut with the saw; internally of a gray colour; insoluble and not to be decomposed in alkalis; soluble in nitric acid, even when weak, but slowly, and with difficulty; only to be decomposed by the carbonats of potash, and of soda, by which it may be analyzed, leaving, after being decomposed and burnt in the fire, a quicklime which is easily known. These *mulberry* calculi, which are pretty often alone, and likewise often covered with uric acid or earthy phosphats, are those kinds which ought the most to resist menstrua injected into the bladder.



*Silex.* These chemists have only met with this earth *Silex.* twice on analyzing 300 calculi with great exactness; hence it rarely enters their composition. It is found mixed with the uric acid, and with earthy phosphats in calculi, the composition of which is very complicated. From it's being so seldom met with, it can scarcely be counted amongst the number of calculous materials.

*Animal matter.* This, which accompanies one or the Animal matter. other of the six preceding materials, and which seems to form their gluten, bond or cement, appears to vary according to the nature of these materials, and may be the determining cause of the precipitation of some or of others; for all, except the oxalat of lime which appears to be a real morbidic matter, are the natural elements of human urine. This animal matter is sometimes in the form of a gelatin, or a sort of albumen; at other times analogous to these, and merits a further investigation.

The old method of classing urinary calculi was, according to their form, colour, size, surface, &c.; Fourcroy makes a new classification. but a more minute investigation of their component parts, and the experiments in particular of Fourcroy and Vauquelin, have induced the first of these chemists to form them into 12 species. On looking over the seven different matters which constitute human urinary calculi, and seeing the constancy by which each is accompanied by an animal substance, it appears there is not one of them that is formed entirely of one species of matter; and the animal substance exists in all, and forms almost always it's gluten; besides, as it has not such influence as to give them any sensible variety in their properties, Fourcroy has not included it in his classification. After having analyzed more than 600 human urinary calculi, and marked the facts this analysis afforded, he has distinguished them into three genera. 1st. Those formed only of one substance, besides the animal matter which

unites their particles. 2d. Those composed of two calculous substances. 3d. Those containing more than two different substances, and often even four. These three genera are divided into 12 species. Of these three alone belong to the first genus.

1. The first species are those composed of uric acid.

2. The second of urat of ammonia.

3. The third of oxalat of lime. Neither the phosphat of lime, nor the phosphat of ammoniaco-magnesia, nor filix, has been yet found alone.

There are seven species in the second genus, *i. e.* among those calculi formed of two calculous substances besides the animal matter, which matter renders them ternary mixtures, as it rendered the first binary. These seven species are as follows :

4. The first contains uric acid and earthy phosphats in very distinct strata.

5. The second, uric acid and earthy phosphats intimately mixed together.

6. The third, urat of ammonia and phosphats in distinct strata.

7. The fourth. The two preceding materials intimately mixed.

8. The fifth. Earthy phosphats mixed together either intimately or in their strata.

9. The sixth. Oxalat of lime and uric acid in distinct strata.

10. The seventh. Oxalat of lime and earthy phosphats in distinct strata.

Lastly. The two last species form the third genus, or those calculi containing three or four calculous substances, viz.

11. The first contains uric acid or urat of ammonia, earthy phosphats and oxalat of lime.

12. The second. Uric acid, ammoniacal urat, earthy phosphats and filix.

Such is the classification which this chemist has formed of the various human urinary calculi, for a more detailed account of which, the reader is directed to his *Système des Connaissances Chimiques, &c.* which has lately been published.

*Calculus of a pig.* This was found in the bladder of a Bertholdi. pig, after having been killed by the butcher. It's weight was rather more than three decigrams, it's specific gravity to that of distilled water, as 19,300 to 10,000. It's Calculus of the pig. form was an oblong oval; it's surface smooth, without any depression, and of a white colour; it was pretty tender, and gave way to the knife. When divided in the middle, the external stratum was very thin and surrounded it on all parts, but was much thicker towards the extremities of it's great diameter, than towards that of it's small one, without showing any determinate crystallization; under this first stratum was a light yellowish zone, beneath which some beautiful crystals of a perfect whiteness were seen, in the form of needles, converging from the circumference to the centre. On analysis, this calculus appeared to consist of phosphat of lime, but from the smallness of the quantity, Bertholdi was incapable of determining exactly the proportion of it's constituent parts.

*Calculus renalis.* The kidneys, like the bladder, are very subject to be the seat of calculi, and as they are perhaps the most exposed of any part of the body to that morbid affection under which concretions are found, they ought to be considered as the source from which the vesical calculus takes it's origin. Indeed, if the kidneys be considered as the natural filters of the urine, it may seem somewhat extraordinary, that such concretions do not take place much oftener than they do. The human frame is very subject to this disease. When these renal calculi are small, they are forced from the kidneys by the

urine, descend by the ureters, and are evacuated under the form and name of gravel. When of a larger size, they press against and wound the canals through which they pass, giving rise to nephritic pains, voiding of blood, &c. Often after having been forced into the bladder, and their size preventing them from passing through the urethra, they become the nucleus of the vesical calculus, which can only be extricated by the operation of lithotomy.

Sometimes they remain in the kidneys, increase in size, by degrees, from a successive addition of several strata, and become so large as to occupy all the canals through which the urine is conveyed from this glandular viscus. In these cases the renal calculus assumes the ramified form of the internal structure of the kidney, the consequences of which are very long diseases, without remedy, very acute and repeated pains, ischurics, dysurics, and evacuations of blood and pus, by the urethra. By degrees, the substance of the kidney is corroded and destroyed by the pressure and continual irritation of these substances, and at last nothing remains but a membrane or sort of bag full of pus, and enclosing the calculus. This dreadful disease, which is not very rare, sometimes continues many years; it even sometimes is present without any of those symptoms which characterize its existence: thus the works of anatomists, and particularly of Morgagni, give the histories of several bodies, which, on dissection, have shown the destruction of one of the kidneys, and the presence of a calculus, without the previous symptoms, though very severe, having led to a knowledge of the cause.

The renal calculus of the human species is of the same nature as the stone of the bladder, according to Fourcroy, who having examined several, found them composed of the concrete lithic acid. They are always perforated,

and full of cavities, in which, as well as on their surface, regular shining crystals of the phosphats of soda and of ammonia are often found; and to examine them, it is only necessary to steep them a few hours in water, during which the crystals disappear, and their nature is discovered by examining the solution.

Animals as well as men are subject to renal calculi. Morand, junior, has even discovered that rats have very frequently numerous concretions in their kidneys, although he appears not to have examined them. A comparative analysis, however, between the human and animal renal calculus, might throw great light on the subject, since the nature of the calculi has great relation to the urine, which differs in various classes. The singular properties of the urine of the horse are well known. This, which is much more charged with matter than the human, becomes turbid the instant it is evacuated. The powdering matter which falls down is found to be for the most part chalk, whilst the precipitation from human urine, particularly towards the termination of certain diseases, is the lithic acid; and it appears from the experiments of Fourcroy, that the nature of the renal calculus of the horse answers to that of the urine of that animal.

The form of this calculus was exactly that of the kidney, the place of which it occupied, and its extremities were terminated by vegetations resembling the cauliflower. It was of a brown colour on its surface, and appeared covered with an infinity of small shining plates resembling fragments of sand, that reflected the rays of light. On its edges were several unequal cavities. Almost all its surface was mammellated, and in some places were portions of membranes. Great difficulty arose on cutting it, from its hardness, but when the instrument had got three or four lines, it passed easily; this arose from the

Renal calculus of the horse.



density of the exterior, whilst the middle was formed of very porous and tender strata. It weighed 15 ounces five drachms 36 grains. It appears, from it's analysis, that one quintal of it was composed of 68 parts of the carbonat of lime, and 22 of the phosphat of lime, both of them earthy insoluble salts. This difference between the nature of the calculus of the horse and that of man, is not extraordinary, after the proof of the existence of the carbonat of lime in the urine of that animal.

Of a cat.

It's formation, according to Fourcroy, is perhaps, more frequent in such animals than is generally believed, as appears from the facility with which these matters are deposited from their urines. Another isolated fact was made by this chemist, from the examination of the renal calculus of a cat. It had been castrated when young; it's renal capsules were found perfectly indurated, and as it were petrified; they appeared to the touch like pieces of stone, and the same grating sharp noise was heard on cutting them with a knife. They were of a whitish colour, and globular grains were easily distinguished, uniting by a very thin cellular texture. Between the largest and most distant grains, the cavities were filled with a thickish ruddy humour. These glands being detached and boiled in a solution of potash, to separate the cellular texture, after which nothing remained but a number of small hard grains of different sizes, and detached from each other, were found (after a few had been exposed to live coals to show they contained no more combustible animal matter, by their not blackening) to contain two insipid and insoluble calcareous salts, viz. the carbonat, and phosphat of lime; the first made about  $\frac{3}{4}$  of the whole mass; the second nearly the remaining quarter. This confirms the opinion, that these capsules are only necessary in the former part of the life of animals, and in adults are no longer of use.

*Calculus arthriticus.* The cretaceous looking substance which sometimes appears in the articulations of gouty patients, and which Severinus had seen of the size of an egg, was originally considered to be nothing more than chalk, from it's great external resemblance to that earth; <sup>Considered as chalk.</sup> but late experiments have shown how little the nature of substances are to be truly judged of by their exterior appearance, unless when accompanied by chemical analysis.

It was supposed by Sydenham, Cheyne, Murray, and several other celebrated physicians, that it was analogous to the matter of the calculus of the bladder; but no analysis confirmed their suspicions; and according to Van Swieten, it never acquires the hardness of the calculus, even after a preservation of twenty years; and Schenkus affirms that this pulverized tufa formed a solid body with water, like gypsum.

The experiments made upon it by Pinelli are worthy <sup>Pinelli.</sup> of attention. He treated three ounces of this arthritic tufa in a retort, and obtained some volatile alkali with a few drops of oil, the residuum weighed two drachms; this substance was tried in spirits of hartshorn, in urine, and in sal ammoniac, but was found to remain insoluble in them; on the contrary, it was perfectly dissolved in the vitriolic and muriatic acids, and even in distilled vinegar. With respect to it's insolubility in acids, Dr. Cullen has since asserted, that it is 'very entirely' so; but Wollaston found, that only the nitrous acid had that power.

Caletan Tacconi, in order to determine by more exact <sup>Tacconi.</sup> experiments the question which was much discussed in his time, whether the principle of the gout was acid or alkaline, chemically examined the synovial liquor of gouty patients; and having observed, that it was equally coagulated by acids and alkalis, concluded, that this disease might originate from both causes, which, ac-

cording to him, ought to conciliate the observations of authors, and direct them in the cure of it. However inconclusive might be his labours on this substance, there is one remarkable fact he mentions, viz. that from some, it reddened the syrup of violets, whilst that taken from others changed it to a green colour.

Roering.

It has also been considered to be the earth of bones; and in the Memoirs of the Academy of Stockholm, for 1783, there is an observation of Roering, stating, that some concretions expectorated by an old man subject to arthritic paroxysms, were found to be of an osseous nature, or composed of phosphoric calcareous salt.

Watson.

Watson, in the *Medical Communications of London*, vol. i. 1784, examined this substance, in order to see whether it was similar to the vesical calculus, as had been represented; but having made some experiments on some that was taken from a gouty patient during dissection, he concludes that it is very different from the matter of the urinary calculus, because it is soluble in synovia, and mixes readily with oil and water, which is not the case with the urinary calculus. Morveau is of opinion, likewise, that it is very different, but he grounds his opinion only upon certain experiments made by Schenkus, Pinnelli, and Whytt, which are far from possessing the accuracy required to clear up the matter.

Morveau  
and Four-  
croy.

The observations of Boerhaave, Hoffman, Springfield, Alston, and Leger, on the good effects of alkaline water, soap, and lime waters, in the cure of arthritic and calculus affections, appear to Fourcroy more proper to ascertain the existence of an analogy between these two kinds of concretions, than the former are capable of disproving it. But as Morveau observes, experience alone is sufficient to decide the question, and this has lately been accomplished by Dr. Wollaston.

At the time this chemist made his experiments, the

prevailing opinion was, that the gouty matter consists of lithic acid, or matter of the calculus described by Scheele. Supposed to be the lithic acid.

But this idea was not founded on any direct experiments, nor, perhaps, more ably supported than by Forbes, who defended it solely by pathological arguments from the history of the disease. Had he undertaken an examination of the substance itself, he would have found, that instead of a mere concrete acid, the gouty matter is a neutral compound, consisting of lithic acid and mineral alkali, which is proved by the following experiments : Discovered by Dr. Wollaston to be lithiat of soda.

1. If a small quantity of diluted vitriolic acid be poured upon the chalk-stone, part of the alkali is extracted, and crystals of Glauber's salt may be obtained from the solution. Common salt may be more easily procured by marine acid. The addition of more acid will extract the whole of the alkali, leaving a large proportion of the chalk-stone undissolved; which exhibits the following characteristic properties of lithic matter.

a. By distillation, it yields a little volatile alkali, prussic acid, and an acid sublimate, having the same crystalline form as the sublimate observed by Scheele.

b. Dissolved in a small quantity of diluted nitrous acid, it tinges the skin of a rose colour, and when evaporated, leaves a rose-coloured deliquescent residuum.

c. It dissolves readily in caustic vegetable alkali, and may be precipitated from it by any acid, and also by mild volatile alkali; first as a jelly, and then breaking down into a white powder.

2. In distillation of the chalk-stone, the lithic acid is decomposed, and yields the usual products of animal substances, viz. a fetid alkaline liquor, volatile alkali, and a heavy fetid oil, leaving a spongy coal, which, when burned in the open air, fuses into a white salt, that does not deliquesce, but dissolves entirely in water, is alkaline, and

when saturated with nitrous acid, gives rhomboidal crystals.

These characteristic properties prove it to be mineral alkali.

3. Caustic vegetable alkali poured upon the chalk-stone, and warmed, dissolves the whole without emitting any smell of volatile alkali. From which it appears, that the volatile alkali obtained by distillation is a product arising from a new arrangement of elements, not so combined in the substance itself.

4. Water aided by a boiling heat dissolves a very small proportion of the gouty concretion, and retains it when cold. The lithic acid thus dissolved in combination with the alkali, is rather more than would be dissolved alone; so that by addition of marine acid it may be separated. While the solution continues warm no precipitate is formed; but as it cools, the lithic acid crystallizes on the sides of the vessel, in the same manner as the crystals called red sand do, when an acid is added to recent urine.

The gouty concrete may be easily formed by uniting the ingredients of which this chemist has found it to consist.

5. If a fragment of lithic acid be triturated with some mineral alkali and a little warm water, they unite, and after the superfluous alkali has been washed out, the remainder has every chemical property of gouty matter.

The acid will not sublime from it, but is decomposed (2.) by heat. The alkali may be extracted by the vitriolic or marine (1.), or indeed by most acids. The compound requires a large quantity of water for its solution (4.); and while warm the solution yields no precipitate by the addition of an acid; but upon its cooling the lithic crystals form as in the preceding experiment.

In each case the crystals are too small for accurate ex-



amination, but this chemist has observed, that by mixing a few drops of caustic vegetable alkali with the solution previous to the decomposition, they may be rendered somewhat larger. At the first precipitation, the crystals from gouty matter were not similar to those of lithic acid, but by redissolving the precipitate in water with the addition of a little caustic vegetable alkali, and decomposing the solution as before, while hot, the crystals obtained were perfectly similar to those of lithic acid procured by the same means.

Such are the essential ingredients of the gouty concretion; and although perhaps in large masses, some portion of common animal fibre or fluid may be found intermixed, the heterogeneous matter is in too small proportion to invalidate the general result that 'gouty matter is lithiated soda.'

The knowledge of this compound may lead to a further trial of the alkalis, which have been observed by Dr. Cullen to be apparently efficacious in preventing the returns of this disease (First Lines, DLVIII.): and may induce us, when correcting the acidity to which gouty persons are frequently subject, to employ the fixed alkalis, which are either of them capable of dissolving gouty matter, in preference to the earths (termed absorbent) which can have no such beneficial effect.

*Calculus pinealis.* It is well known, that nothing is more common than to find several small stones or concretions in the pineal gland of the brain; both in the human and that of quadrupeds; but either on account of their smallness and the difficulty of procuring a certain quantity, or the little account of the utility of the investigation, nothing has been attempted until Dr. Wol-

Dr. Wol-  
laston.

and by this he found that it formed the basis of the particles of sand to be felt in this gland; for after they were calcined they crystallized perfectly from marine acid. But he is of opinion that this sand, which from it's frequency scarcely merits the name of disease, or when amounting to a disease, is most certainly not known by it's symptoms, would at the same time, if known, be wholly out of the reach of any remedy.

*Calculus prostaticus.* The calculus of the prostate gland, which may be considered, as well as the vesical, to be a concretion of the urinary passages, has also been examined by Dr. Wollaston, who thought it merited an investigation, not from the frequency of it's occurrence, but from having been supposed to give rise to stone in the bladder.

It appears in the form of small stones occasionally in this gland, and those which this chemist had an opportunity of examining were from the size of the smallest pin's head to that of pearl barley, in colour and transparency like amber, and appeared originally to have been spherical; but from contiguity with others, some had flattened surfaces, so as at first sight to appear crystallized.

These were found to be phosphorated lime in the state of neutralization, tinged with the secretion of the prostate gland.

1. A small fragment being put into a drop of marine acid, on a piece of glass over a candle, was soon dissolved; and upon evaporation of the acid, crystallized in needles, making angles of about  $60^\circ$  and  $120^\circ$  with each other.

Water dropped on the crystals would dissolve no part of them; but in marine acid they would redissolve and might be recrystallized.

2. Vitriolic acid forms selenite with the calcareous earth.

3. By aid of nitrated quicksilver, phosphoric acid is readily obtained.

4. When heated, this calculus decrepitates strongly; it next emits the usual smell of burnt animal substances, and is charred, but will not become white though partially fused. It still is soluble in marine acid, and will in that state crystallize more perfectly than before. Hence he concludes, that these stones are tinged with the liquor of the prostate gland, which in their original state (1.) somewhat impedes the crystallization. This crystallization from marine acid furnished the before mentioned test.

This chemist is of opinion, that the calculi of the prostate gland are too rare perhaps to have been ever yet suspected in the living body, and are but indirectly worthy of notice: For if by chance one of them should be voided with the urine, a knowledge of its source would guard us against an error we might otherwise fall into, of proposing the usual solvents for urinary calculi.

Dr. Wollaston has also met with neutral phosphorated lime in a very pure state and soft, contained in a cyst under the pleura of costalis.

*Calculus stomaticus*, or bezoard. In the human stomach, although stony calculi in strata have been found, yet it is very rarely; whilst on the contrary, in that of quadrupeds it is not uncommon to find hairy balls agglutinated by a lymphatic juice; and there is a species of calculus found in the stomach of some, called the bezoard, which is in high estimation.

The origin of the name bezoard is uncertain, whether it is derived from pazan or pazar, the name of a buck in the Persian language, or beluzaar, which signifies an antidote in the Hebrew, or Chaldean language. Dau-

*Calculus  
stomaticus,  
r bezoard.*

*It's etymology.*

benton is of opinion, that the name was only given to certain concretions found in the bodies of some Asiatic animals, perhaps the gazelle, antelope, or goat of India, as from the account of travellers they very much resemble them; it is however very certain, that the animals are of that class, viz. with cloven feet, and provided with horns.

After the discovery of America, the name of bezoard was also given to the concretions found in the animals of that part of the world, such as the pard, chamois, or the goat of Peru. Bezoards are also taken from the porcupine, wild boar, tortoise, horse, mule, dog, castor, ox, rhinoceros, elephant, man, &c. and are of all sizes.

Distinguish-  
ed into two  
kinds.

Bezoards are distinguished by the names of oriental and occidental, from the parts in which they are procured; the first is the most scarce and of much greater value than the other. The ordinary bezoard is taken from the common domestic goat.

1. Oriental  
bezoard.

The oriental bezoards which are taken from a species of deer in Egypt, Persia, China, and several other parts of the East Indies, are internally and externally of a brown olive colour, generally of a deep hue, and even, blackish, the surface shining and polished.

2 Occiden-  
tal.

The occidental bezoards are internally of a whitish colour, but their external surface is not so shining, nor so polished as the oriental. The surface is whitish, mixed with yellow or black, most often with shining tinges, which appear to be gilt or bronzed.

Composition  
of bezoard.

Bezoards, according to Bomare, are composed of concentric strata, which are not all of them the same colour or thickness; the flavour is urinous, they are glutinous, and tinge slightly the saliva. At the centre of the bezoard, some foreign body is almost always found, such as straw, hair, grains of corn, wood, nuts, &c.; and

these bodies have served as a nucleus or point for the formation of the strata. Sometimes they rattle on shaking them, which is produced by the hard body in the centre having been detached.

Great sudorific virtues have been attributed to the bezoards, especially to the oriental, and they were believed to be an antidote against poisons. Their price rose according to their size, and from their high value, factitious ones have been substituted, and those compositions which go by the name of pierres de Goa, or de Malacca, are false bezoards.

Superstitious ideas of them.

According to Bomare, they are made in the following manner: Lobster's claws, and oyster shells levigated on porphyry are made into a paste with musk and ambergris, then formed into balls of the form of bezoards, which are afterwards rolled upon gold leaf. Those who are desirous of a more exact imitation do not gild them. This however would be necessary to imitate those of the ox, if it be true that they are of a gold colour, and of a metallic brilliancy, when the first strata have been taken away. These factitious bezoards are distinguished by drawing a line with them over a piece of paper that has been rubbed with ceruse, chalk, or lime; if the trace becomes of a greenish or olive yellow, it is a sign of it's being natural; those that are real, imbibe water and alcohol, render them turbid, and effervesce with acids.

Method of falsifying the oriental.

Of all the bezoards, the *piedra del porco* is the dearest. It is fat and soapy to the eye and touch, of a greenish or yellowish colour; also reddish or blackish ones are found, and it is almost incredible how highly they are valued in Holland. Bomare saw one about the size of a pigeon's egg, belonging to a Jew, at Amsterdam; who asked 6000 livres for it. They are let out both in Holland and Portugal at a ducat a day to those

Value of the real ones.



who fancy themselves attacked by contagion, and who think they are preserved from it by carrying them as amulets in the same manner as eagle stones are used in Germany, to facilitate difficult labours, the load-stone in France to cure a fever, or the jade in Spain, to prevent the gravel. Such is the striking portrait in these countries of the superstition and folly of the human mind.

Bomare looks upon the bezoard to be a stone found in various parts of certain animals, as the stomach, salivary canal, intestines, gall-bladder, and the kidneys, from which it appears that the knowledge of this natural historian was very limited with respect to this calculus, and that it only was extended to its medicinal use.

The observations of Daubenton are much more satisfactory, more particularly those which he has given of the natural historical part. Having, in comparing the *fossile* with the *oriental and occidental bezoards*, described the formation and nature of the first, he proceeds thus to the description of the last.

Their formation.

All animal bezoards are composed of concentric strata, some have, at their centre, a foreign body, the nucleus around which the first stratum is formed; in the oriental various substances form this nucleus, such as marcasite, talc, flints, gravel, straw, grass, wood, seeds of plants, cherry stones, those of the cassia, tamarind, &c. These different substances, and principally the seeds of plants, which are in the centre of the oriental bezoards, afford reason to believe that they are formed in the stomach or intestines of animals. Their nuclei, according to Daubenton, show the impossibility of their being formed in any other parts of the body from their difficulty of penetrating there: on the contrary, those substances may easily enter the alimentary canal with

the food ; and this historian has found in the paunch of oxen, after dissection, great numbers of gravel stones, which might have become the nuclei of the bezoard.

Bontius says, that the oriental are formed in the bellies of animals, of which there are numbers in the different provinces of Persia. Kæmpfer, who inquired in Persia in what parts they are found, relates, that it is in the pylorus or the bottom of the fourth stomach ; that if their origin is not there, the bezoard at least remains some time in that situation, where it increases in size, and that if it be not prevented by the plaits of the stomach, it passes through the intestines, and is excluded with the excrements ; but this account is without proof, no observer having as yet opened an animal that contained these calculi, so as to be able to determine their situation. Kæmpfer has only related what he has heard.

The observations of Daubenton on the formation of these calculi induce him to think they originate in the stomach and intestines. He has remarked on the dentes molares of the ruminating tribes, a stratum of blackish shining matter, of an external brilliancy resembling gilt or bronze, and in those places where this matter is thick, it covers a whitish tartar. He had likewise observed a similar matter on many occidental bezoars, and possessing the same brilliant gilt hue, and this stratum he thinks could only proceed from the herbs, the expressed juices of which became attached to the teeth during mastication, and from a sort of tartar analogous to the concrete juices of crude vegetables which they eat. He thinks there is no doubt but that the same juices which become thick and hard on the teeth, do the same on the external surface of the strata of these bezoards in the stomach and intestines, since the gilt and bronze are similar on both bezoard and teeth. The oriental bezoards are without these, but their surface is as shining as the mat-

ter that covers the teeth, it has the same ground of colour, and their substance appears to have a great relation to the concrete juices of plants; the strata are of different thickness, but almost all of them have the same polish on their external surface.

The form of this calculus depends upon it's nucleus; they are generally more or less round when composed of a small number of strata; some are oblong, angular, and very irregular.

When a bezoard ceases to acquire new strata, the more convex parts of those already formed become worn, which appear then like an agat-onyx, but lose nothing of their hardness in the body of the animal, although Kæmpfer asserts that it is neither hard nor solid in the animal. He appears to have been better informed when he attributes the difference of formation of it to the quality of the herbs which the animal takes in as nourishment; for the glutinous, aromatic, resinous plants, growing upon the elevated parts of the hot countries, must receive from the soil, the air, the action of the sun, juices proper to form the oriental bezoards. The substance of the body also contributes to this, since it does not appear, that every species of animal produces bezoards, even in hot climates. This bronze only covers the strata of the occidental, and does not penetrate their internal part, or at least it does not carry with it it's brown colour as in the oriental, for the internal substance is white or yellowish; the crystallization of this occidental bezoard is very regular, for if one of the strata be broken, small transversal shining crystals appear, which are found to be crystallized needles directed from within, externally. The largest extend from one surface to the other, and between them are smaller, appearing like branches of the larger; they are all ranged transversely in small whitish lines, placed very near each other, and parallel to the sides of

the strata; those which cross the strata, and which are themselves crossed by parallel lines, Daubenton thinks, may make the distinguishing character of the occidental, found in the stomachs or intestines of ruminating animals.

Having thus given the principal outlines of the ideas of Daubenton, respecting the formation of this calculus, Fourcroy's account of them. there remains to add to what Fourcroy has given us on this subject some observations, from which it follows, that,

1st. The bezoard is only found in abundance in animals of hot climates, those which inhabit the temperate zone are more subject to ægagropilæ.

2d. It is only in the stomach and intestines of frugivorous or herbivorous animals that bezoards are met with, the carnivorous class being exempt from them. The conclusion, however, of some authors is erroneous, who think they are always to be looked upon as the residua of vegetable nourishment.

3d. If, according to this idea, more virtues are attributed to the oriental, on account of the herbs that grow on the mountains of Asia, it is erroneous, there being plants in America as aromatic and sharp as in the Indies, and the bezoards consequently ought to partake of their virtues.

4th. Instead of looking upon them as the residua, they ought to be considered as concretions of the different saline substances deposited, and more or less crystallized in the different cavities of animal bodies, according to the nature, properties and quantity of the liquids which held them in solution.

5th. Bezoards not only appear to differ in their nature, according to the species of animals that produce them, but they are essentially different from each other in the same animal, according to the places they occupy. The same takes place in the human body; the calculi found in



the gall bladder are very different from those found in the kidneys and bladder.

6th. The pretended method of distinguishing the true from the false bezoard by the greenish trace on paper covered with ceruse or white lead, is not founded on fact; the false, if they contain only animal matter, will do the same, as it arises from the sulphureous hydrogen gas disengaged by the putrid fermentation.

7th. The bezoard, although the oriental is used in medicine, has not as yet been chemically examined; the bezoards of vegetables ought likewise to be more attended to. It is well known that the bamboo often contains a concretion called tabasheer by the Arabs, which several English have found to be composed almost entirely of silica.

Fourcroy has seen in the cabinet of Jussieu, white, yellowish, or milky spheroid bezoards, polished on their surface, and similar to ivory; he was told they were produced by the cocoa; but nobody has yet investigated the vegetable bezoards, a great deal is therefore wanting before we can arrive at any perfect knowledge of these animal concretions.

Dr. Pearson.

Dr. Pearson, who examined one of the oriental species, found it to consist of vegetable matter only.

Three kinds.

*Calculus intestinalis*. This species of concretion is found in the intestinal canal of both man and beast, and may be distinguished into two kinds, according to the cavities in which it is formed. The first comprehends those which, having been formed in the organs or viscera adjacent to the intestinal canal, have descended into it by means of ducts communicating with it.

2d. Those immediately formed in the intestines. Besides these two, perhaps a third sort may be admitted, or those which after having been in the adjacent viscera and



deposited in the intestines, have, during their abode there, been covered with a strata of concrete matter proceeding from the liquids contained in the intestines.

The first are almost the only concretions found in the human subject; they are almost all of them biliary, which, after having been formed in the gall bladder, descend by the ductus coledochus, where they remain more or less time, although in general they are immediately carried off by the anus.

The second, or those formed by the induration or crystallization of the juices contained in the intestines, are in the human body extremely rare. They are found not uncommon in other animals, and horses are very subject to them.

One of these was examined by Fourcroy; it was found in the colon of a horse that had died of the gripes, in the year 1785; its analysis presents some curious facts.

Cal. int. of  
a horse,  
analysed by  
Fourcroy.

It was of a gray colour, its external surface appeared to be formed of rays diverging from the centre to the circumference, its form was pretty regularly round, its diameter five inches, and weight five pounds; when cut in two, the parts that formed it arose from a common point the centre, diverging every way so as to form a sphere of eighteen inches in circumference. The centre of this sphere presented some cavities in which were to be observed fragments of vegetable matters, hay, straw, oats, which exhaled the odour of these substances when somewhat changed.

It was insoluble in cold water, even when reduced to a fine powder.

In boiling water, this powder, however, was slightly soluble, and from its analysis this chemist concludes, that it was a triple salt composed of about two parts of phosphat of magnesia, one part of phosphat of ammonia, and one part of water. In accounting for the formation

of this calculus, he conjectures that the magnesia, which is so rarely found in animal matters, might have been introduced into the animal when administered as a remedy in some disorder, and by meeting with the phosphoric acid, and phosphat of ammonia, gave rise to this insoluble triple salt which formed this calculus ; for this, however, to have taken place, the magnesia must have remained a long time in the canal, and the animal must have been a long time without rendering his excrements.

By Barthol-  
di.

The analysis of Bartholdi, upon a calculus of the same species, perfectly agrees with that made by Fourcroy. It was found in the rectum of a horse, and an account of it is given in a letter to Vauquelin. He supposes it to have been found in the colon, and not to have been deposited in the rectum but a few hours before it's death. The animal belonged to a miller, and died of the gripes. It weighed about thirty-one ounces and half. It's form was round, oval, depressed toward it's edges, and rather dented on one side.

It's specific gravity was to that of distilled water, as 16667 to 10000, and that of a detached portion as 16700. It was of a brownish gray colour ; it's diameter in length four inches two lines, and in breadth three inches. Being cut in two, it appeared composed of many spherical strata, between the first and second of which was found an interstice of one line in breadth, and ten long, or rather in circumference, filled with bran and earthy matters. On the same side was observed a slight dent. Half being again divided, the principal strata appeared to the number of eight, some of which were composed of thinner layers, but so well united as not to be separated without breaking the principal ; each of these was composed of small crystals placed vertically. In the centre was found a small plate of iron, very thin, and about two inches in circumference.

It was completely soluble in the sulphuric, nitric, and muriatic acids; without any effervescence, likewise in distilled vinegar at the common temperature, a little residuum remained. The phosphoric acid, when pure, and prepared by a slow combustion, entirely dissolved it. Water had no effect upon it. From its analysis, it was found composed of

O, 18 of white magnesia.

O, 26 of phosphoric acid.

O, 032 of ammonia.

O, 46 of water.

O, 04 of animal matter.

This chemist observes, that the facility with which the acetous acid dissolves it, presents a method of cure by glysters of vinegar, which at least are harmless. It has been said that these calculi are principally found in horses used by millers, and this chemist thinks that the bran, as a food, may have some effect in producing them, since this always afforded him magnesia; but whether their formation is owing to this skin of corn, or other grain, or to the earthy parts detached from the millstones in the act of grinding, being composed of granite that contains white magnesia, has not as yet been ascertained.

*Calculus salivaris.* It is not uncommon to find hard stony concretions in the salivary glands, particularly in the parotid and sublingual. The calculi formed in the first glands have been known to descend into the duct, and produce a swelling, an abscess, and in consequence, a salivary fistula; whilst those in the second glands are said sometimes to form abscesses, by which means they eject themselves. The authors who have described these diseases, have in general attributed the origin of the calculi to a thickening of the saliva, or the coagulation of this animal fluid, as several have expressed it.

Method of  
cure.

Authors on  
the subject.

Haller, in treating of the nature of the saliva, admits with Fauchard, that the earthy sediment it contains is the source of the crust of the teeth, commonly called tartar; and adds that the salivary calculi, which he attributes to the same matter, are so frequent in the duct of the maxillary gland, that it would be difficult to find in the human body a part more subject to calculi. He supports this assertion upon the testimony of Severin, Meibomius, Hagedorus, Eller, Kramer, Slevogt, Walter, Van Swieten, and Scherer, the last of which authors has written a particular dissertation on this subject. Haller has seen the ranula, a disorder which consists in the inflammation and consequent abscess of the neighbourhood of the frænum linguæ, produced by a salivary calculus in the duct, and cured by the extraction of the calculus; and several authors give accounts of the production of the angina from the same concretion. Hippocrates, in the second book of his Epidemics, had already made mention of small stones situate under the tongue, consequently salivary calculi must have been known to him; but no one had examined their nature, or even attempted the slightest chemical investigation of their properties, until Fourcroy, on making some experiments upon the tartar of the teeth, found, that this solid deposit was of the same nature as the basis of the bones; and this has since been confirmed by Dr. Wollaston, who informs us that the two specimens of this incrustation which he examined, consisted of phosphat of lime, with a very small excess of the earth. It appears that the human salivary calculus is the only one that has as yet been analysed, and there remain those found in the glands of other animals, as the horse, ox, sheep, &c., before any thing complete can be looked upon on the subject. The nature of those in the amygdala is entirely unknown.

Tartar of  
the teeth  
examined  
by Fourcroy  
and Wollas-  
ton.



*Calculus muscularis.* These are granular concretions, angular, or irregular in their form, situated between the fleshy fasciculi; they are rarely to be met with, and appear when they do exist to be in consequence of arthritic diseases of long standing; but they are so scarce that Fourcroy was not able to procure a single specimen. Besides these which may be called *muscular calculi*, the fleshy parts are liable to be affected by osseous concretions, as is often the case in old animals, when the extremities of the tendons and the sides of the sanguiferous vessels become partakers of the same disease.

These *ossifications* have been examined by Dr. Wollaston, who found, that what he procured from the arteries and valves of the heart consisted of the same principles as the earth of bones, and retained in like manner the redundant calcareous earth, on which account they are very properly called ossifications. This chemist looks upon those of the veins, the bronchiæ, and of the tendinous portion of the diaphragm, to have the same excess, although his experiments upon them were made too long since to speak with any certainty.

*Calculus pancreaticus.* These concretions have been found in the human pancreas, and are said to bear a great resemblance to the salivary concretions.

*Calculus pulmonarius.* According to Fourcroy, it is not uncommon to see patients, after a cough of long standing, and particularly old people who have been very subject to arthritic affections, expectorate concretions from the lungs in very small pieces; and similar ones are found sometimes in the lungs of those who have died in consequence of complaints of that organ, or from serofulous affections. On cutting into the lungs, they are easily perceived by their grating noise against the knife.

*Calculus uterinus.* Hard concretions have also been met with in the uterus, which are looked upon as real



calculi. These, however, have no relation, nor are to be confounded with those irregular masses that go by the name of false conceptions.

Haller's *Physiol.*—Macquer's *Woerterbuch* von Leonhardi, article *Blasenstein*. — Tyfchen's *Untersuchung eines Blasensteins*. Crell's *Annal.* t. 2. 1786.—Scheele's *Essays*.—*Encyclopédie Méthod.*—J. Hartenkeil, *præs. Casp.* Siebold, de *Vesicæ urinæ Calculo*. Vincebur. 1785.—*On Gouty and Urinary Concretions*, by Wm. Hyde Wollaston, M.D. F.R.S. *Philosoph. Trans.* p. 386. part. 2. 1797.—*Experiments and Observations on the Composition and Properties of Urinary Concretions*, by George Pearson, M.D. F.R.S. *Philosoph. Trans.* p. 15. p. 1. 1798.—*Analyse de Calculs*, par A. F. Fourcroy. *Annals de Chimie.* vol. 16, p. 63.—Baillie's *Morbid Anatomy*.—Bartholdi, &c. *Ann. de Chim.* v. 23, p. 123.—*Observations sur la Nature du Calcul de la Vessie*, par le Cit. Brugnatelli, *ibid.* v. 28, p. 52.—*Lettre du Cit. Fourcroy au Cit. Giobert.* *ibid.* v. 30, p. 57.—*Sur l'Analyse des Calculs urinaux humains par les cit. Fourcroy and Vauquelin.* *Annal. de Ch.* No. 95, p. 213.—*Sur un Calcul urinaire de Cochon, &c.* par le cit. Bartholdi. *ibid.* p. 165.

## CALCULUS BILIARIS, BILIARY CONCRETIONS, OR GALL STONES.

THESE are light inflammable concretions, found in the gall bladder, and evacuated along with the fæces. They are produced by the gall in a diseased state of that excretion, and particularly in those diseases which some physicians have called spasmodic, in hysteria, and melancholy. These, by detaining the gall in the bladder, are said to give rise to these concretions. They likewise are the cause of other diseases, particularly the jaundice, and appear to be, with respect to the above viscus, what the vesical calculus is to the bladder.

The lightness and inflammability of gall stones, have been long known. Glisson, Bianchi, Hoffman, and others, have described some of their varieties and properties; but the first who attempted to arrange them methodically, was Walther, a celebrated anatomist of Berlin: he has divided them into three classes, after the method of naturalists; 1. lapilli striati; 2. lamellosi; 3. corticati. Vicq d'Azyr has likewise made an arrangement into three classes. In the *first*, he has placed those biliary calculi formed of a yellowish bilious matter, whether filamentous or not. The *second* contains those composed of a more or less shining crystalline matter, with or without a covering; and in the *third*, he puts the mixed calculi, or those in which the yellow bilious and crystalline substances are found united.

There is a great variety in the external appearance of gall stones, as they not only differ in their colour, but in their shape. Some are of a white colour, others black; some are yellowish, others greenish, and others are of a

Arrange-  
ment into  
classes by  
Walther and  
Vicq  
d'Azyr.

light brown, a dark brown, or a reddish brown colour; the different shades between these are likewise numerous, and not easily to be expressed. With respect to their shape, there is also a great difference, some being very smooth, others rough and tuberculated, some are roundish, others oblong, and angular. They also differ in their structure, although when cut or broken, they are generally found to consist of concentric laminæ externally, and in the centre are of a radiated texture. The laminated part, according to Baillie, bears sometimes a large proportion to the other, whilst at other times the contrary occurs. The laminated and radiated structures are sometimes compact, and at other times consist of a loose matter, whilst it occasionally happens that both these structures are very obscure, and they appear to be a very uniform solid mass. The laminated part likewise on the outside, very frequently consists of a different substance; in appearance, from the radiated structure in the centre, and it is not unusual, as Baillie affirms, to find the structure in the centre to consist of shining white crystallizations, which have a good deal the appearance of *spermaceti*.

With respect to their taste, very few, according to the observations of the above author, have a bitter flavour, which is a reason he thinks that they do not consist of inspissated bile; in some, however, he found the flavour intensely bitter.

From the great variety of appearance which these calculi assume, it is evident the difficulty of arranging them into any method must be great; but Fourcroy, to whom we are indebted for the best analysis, has divided them into three varieties.

Divided into three varieties by Fourcroy. 1st. Those of a brown or blackish colour, with irregular or tuberculated surfaces, and formed as it were of lumps.

2d. Those which are yellowish or greenish, harder in their texture than the last, formed of concentric strata, and often covered with a dry uniform crust; the shape of these is generally angular and polyedrous.

3. The last variety comprehends the white and ovoid concretions, which are more or less irregular; they are covered with a whitish, and often unequal rind, and formed, as it were, of spathic strata, or transparent crystalline lamellæ, and are often radiated from the centre to the circumference.

Besides this division of gall stones, from their external and internal appearances, he has likewise distinguished them according to their chemical analysis, or the proportion of the principles of which they are formed, into two species, viz. into those which are composed only of a shining, foliated, crystalline substance analagous to spermaceti, and into those which contain, with a more or less quantity of this crystalline substance which appears to form the basis or kernel, a thickened bile or extract, in the midst of which the first substance appears to have been confusedly crystallized.

And into two species from their analysis.

Gall stones are specifically lighter than water, and swim upon it's surface; some, however, are found to be specifically heavier, but of these there are very few. One that Gren weighed was to water as 0,803 to 1000.

Exposed to the flame of a candle, they melt like wax, and become inflamed, but do not smell like any of those animal parts that afford a volatile alkali by distillation. Baillie, however, met with a very black species that did not melt, but burned exactly like a cinder.

Inflammation.

By dry distillation in a retort to which a pneumatic apparatus was adapted, we are informed by Gren, that some hydrogen and carbonic acid gas was obtained, and a yellowish empyreumatic fluid of a bitter flavour, that scarcely reddened the tincture of litmus, did not precipi

Distillation.

tate limewater; and on the addition of a fixed alkali, volatile alkaline fumes were extricated: there arose likewise a brownish empyreumatic oil. Teichmeyer received a yellow, then a red, and even a black empyreumatic oil. The remaining coal Gren found to amount to  $\frac{1}{8}$  of the weight of the gall stone; it was of a shining appearance, of a blackish colour, extremely difficult to incinerate, and being dissolved in nitrous acid, was found to be phosphat of lime.

Water.

According to Haller, very few show any solubility in water, even when it is impregnated with fixed air; some, however, as Hildebrandt observes, communicate a bitterness, and a little colour to the water in which they are boiled, although no solution takes place.

Vitriolic acid.

According to Gren, pure vitriolic acid, when concentrated and added to pulverized gall stone, became very warm; sulphureous gas arose, the mixture assumed a dark brown colour, and on reposing, the gall stone swam on the surface in a fluid state, as long as the heat lasted. On being stirred, there was no solution, but in a few days after the gall appeared like a black resinous coagulum, exactly in the same manner as with fat vegetable oils, or animal fat. The decanted acid, on the addition of much distilled water, let fall a gray flocky matter, similar to coagulated lymph. Delius found that the diluted mineral acids had no menstrual effect on gall stones, yet the vitriolic acid as well as the muriatic received a green tinge. Baillie found, that they separated in this acid into a fine black powder, especially in a sand heat. According to Hildebrandt, they detonate with nitre very strongly.

Nitre.

Nitrous acid.

The concentrated nitrous acid became very hot, as Gren informs us, on the addition of pulverized gall stone, and attacked it, which gave rise to a large quantity of nitrous gas. In this acid some are entirely dissolved, others not, but melt to a yellow oil, which swims on the surface



during the heat, and on cooling become coagulated to a yellow substance like wax. The decanted acid, Gren found, on adding much distilled water, let fall the dissolved albumen in the state of flocks. Hence it appears, that they consist of a coagulable lymph, and a substance similar to wax. Delius found, that this acid became of a red colour on their addition: Hermbsstadt, that diluted nitrous acid had likewise a menstrual effect on them by the assistance of heat, and afforded saccharine acid; and all that Baillie examined were soluble in this acid.

Gren found, that by the use of concentrated muriatic acid the flocks separated the best; whilst Baillie found, that they are but little effected by it in a sand heat. Limewater, according to Whytt and Gren, does not dissolve them.

From the experiments of Delius, it appears, they are very little or not at all soluble in carbonated alkalis; whilst Hildebrandt affirms, that the lye dissolves most of them. They are however, easily dissolved in caustic alkalis, particularly by the aid of heat.

Neutral salts, as well as soaps, have no effect upon them, in which the experiments of Conradi agree with those of Gren.

All oils, whether fat or æthereal, as they have been called, and particularly the oil of turpentine, dissolves them by heat. Baillie found, that most gall stones were somewhat soluble in the oil of turpentine at the heat of the atmosphere, but not in any considerable degree; and one species he found insoluble; some were converted into a kind of oil, that sunk to the bottom; others that were partly soluble tinged it of a brown colour, and were partly separated into a powder.

According to Baillie, gall stones are but little affected in the common temperature of the atmosphere by alco-

The production of a scaly crystallized substance.

hol, but are either partly or totally soluble in it at a boiling heat. Gren affirms, they are not dissolved by the highest rectified spirit of wine, and that the extraordinary appearance the gall stone puts on in alcohol is not a solution, as many chemists have supposed. For instance, if pulverized gall stone be mixed with alcohol, then well shaken, and digested in a moderate heat, it will be found, on repose and becoming cool, to have formed uncommonly beautiful, shining, scaly crystals, which have the appearance of sedative salt. According to Gren, this matter, which Poulletier de la Salle took for a salt, is nothing but undecomposed gall stone, the parts of which being melted by the heat, puts on this beautiful crystallized appearance; for he found it was soluble neither in alcohol nor water, nor communicated to the last the least trace of an acid or of a saline nature.

First discovered by Conradi.

As this shining scaly matter forms one of the most curious parts of the analysis of gall stones, it will be necessary to give a circumstantial account of its discovery and properties. It was first observed, I believe, by Conradi, who extracted it by means of dulcified nitrous acid; then by Poulletier, by means of alcohol; and is found by Fourcroy to bear a great resemblance in its properties to spermaceti.

Poulletier.

Poulletier having examined the biliary calculi of the second variety, observed they were soluble in alcohol. Having digested them with good spirit of wine, he remarked, that after a certain time this liquor was filled with very delicate, shining, crystalline particles, having all the appearance of a salt. His experiments on this substance gave him reason to suppose, that it was an oily salt, analogous in some of its properties to the acid salt called the flowers of benzoïn; but it appears, he knew nothing further of its nature. This salt he thought was only contained in the human gall stone, as he was not

able to find it in that of the ox. This very singular circumstance merits confirmation, for Fourcroy and Vauquelin have found a small quantity of lamellated matter in the calculi of that quadruped.

The discovery of this matter has elucidated several facts that had been collected by the Society of Medicine at Paris, on the calculi of the gall-bladder. This society received from it's correspondents some of those of the third class, which had not been described. They were masses of transparent crystalline lamellæ, resembling mica or talc, and absolutely of the same form as the matter extracted by Poulletier. It appears, that the human bile is capable of furnishing a great quantity of these crystals, as the society has in it's collection a gallbladder intirely filled with this transparent saline concretion. Fourcroy informs us, that he received from Lepreux and Halle, two bladders full, perfectly similar, from which examination he found, they were of an oily nature, analogous to that of spermaceti.

Found to be  
analogous  
to sperma-  
ceti by  
Fourcroy,  
and forms a  
peculiar  
species.

It will not be improper to give a general view of the experiments that led Fourcroy to this conclusion, and may be found more in detail in the Third Volume of the *Annales de Chimie*.

He informs us, that more than twenty years are elapsed since the late Poulletier de la Salle, wishing to know the nature of biliary calculi, and determine their solubility in alcohol, from what Senac had told him was mentioned by Valisneri, found, that these concretions deposited, in proportion as the alcohol dissolved the greatest portion of them, a foliated, shining, lamellated substance, pretty similar to the boracic acid. He was desirous of separating these crystalline lamellæ from the solution, and collect them upon a filter, but soon found they were so light, that although in appearance they occupied

a great space in the solution, they were, on desiccation, reduced almost to nothing.

The small quantity he collected being put upon a hot coal, immediately disappeared in smoke and vapours. This circumstance was simply announced in Macquer's Dictionary of Chemistry; but Macquer did not indicate, any more than Poulletier, the nature of this singular substance. Fourcroy having had frequent occasions of making chemical experiments with Poulletier, and their conversation often turning on the subject of biliary calculi, Fourcroy first lays down the facts he learned from the last chemist, and afterwards what he discovered himself respecting this peculiar substance, in the following manner.

1. The crystalline matter appears more soluble in warm than in cold alcohol; this warm liquor passes very clear through paper, but the matter separates from it so readily, that Poulletier believed it to have passed with the alcohol. It is scarcely soluble in cold alcohol, *i. e.* at ten or twelve degrees, as forty-eight grains were deposited out of fifty on cooling, yet the liquor continued to deposit a little on the addition of water.

2. This matter appears to vary in quantity in different human biliary calculi, though it constantly exists in all.

3. The proportion is very inconsiderable, for a few grains are scarcely obtained from a drachm of the calculi.

4. The calculi of quadrupeds, and particularly of the ox, are soluble in alcohol, but contain no crystalline matter. These are the four facts which Fourcroy collected from Poulletier himself; he then gives an account of his own discovery. It appears, that he had kept for several years two gall bladders, absolutely full of biliary stones; when in 1785, the discovery he had made on the oily nature of the dried liver, induced him to examine what might be the nature of biliary concretions.

The stones he made his experiments upon, were polished, quadrilateral, lying on each other, externally gray, and internally of a brown green colour; he found that two pounds of alcohol were scarcely sufficient by aid of a gentle heat to dissolve two ounces of these pulverized calculi. The more hard and brown parts even refused. The warm solution when filtered was very clear, and of a yellow or slight green colour; on cooling, it quickly deposited a great quantity of white brilliant crystals, resembling those of concrete boracic acid. This experiment proved this matter had been dissolved by the warm alcohol, and was precipitated on its cooling. Nearly one drachm of these crystals was collected on a filter, and had the properties of spermaceti, for which, *vide* animal oils. This proved to Fourcroy the great analogy between this and the dried liver, as well as spermaceti, and left him no longer in doubt but that its source must have been in the liver itself. A third fact, as important as the preceding, proves the truth of it.

It is not many years ago since Walther, but more particularly Vicq d'Azyr, described with great care a peculiar species of biliary concretions, different from those commonly found in the gall bladder, *i. e.* cystic calculi, rounded, or in polygons, formed of concentric strata, gray externally, brown internally, but never so numerous in the bladder as the first; it has likewise never been found full of them, but on the contrary, with ordinary biliary stones, whilst here rarely more than one is found, although more considerable in size than the common ones. These solitary concretions are sometimes as large as a pigeon's egg, but in general do not exceed the size of the egg of a small bird. Their figure is nearly ovoid, sometimes cylindrical, almost always rounded, but rarely unequal externally; their colour is white, on breaking; instead of brown concentric strata or bile simply thick-



ened, and deposited in strata as in the most common of these calculi, they have a lamellated crystalline or striated structure, shining, white, soft and unctuous to the touch. Sometimes this concretion, instead of offering large plates of the size of it's diameter, only presents *strixæ*. It also varies in colour, for instead of the white shining, silvery, or micaceous appearance, it is sometimes yellow or greenish. It is often intermixed with brown bile in a mass; a nut of thickened bile is always observed in it.

After Haller, who gave in a dissertation in 1749 many facts on biliary calculi, we are informed by Fourcroy, that Walther has the best indicated the species under consideration; but Vic d'Azyr has treated the subject with more care and exactitude than even Walther.

Vic d'Azyr, however, remarks with reason, that chemists as yet are not thoroughly acquainted with the nature of these concretions; he observes, after having described all the varieties, and as it were all the shades of these animal crystallizations, from the common biliary stone, even to that which is formed of this crystalline matter, that this last substance appears to be the same as that found by Poulletier de la Salle, in common biliary stones. In effect, it's chemical properties, according to Fourcroy's experiments, are perfectly analogous. These crystalline biliary concretions become soft, and melt by heat like wax; but at a lower temperature, and absolutely like spermaceti. They become fixed and crystallized on cooling. Water has no effect upon them. Hot alkali dissolves them; whilst a great part separates on cooling in the form of brilliant talcyl lamellæ. In a word, they presented Fourcroy all the properties of the residue of the dried and putrid liver, and of the brilliant crystals which alcohol separates from the calculi of thickened bile.

Gren analysed a stone which was of a yellow colour, and smooth to the touch, of a similar nature to those examined by Fourcroy; but Gren affirms that it was not soluble in alcohol, whilst Fourcroy was able to dissolve his in it with heat entirely. Gren concludes from his own experiments, that this gall stone was composed of eighty-five parts of cerous matter, and fifteen of lymph.

It will not be amiss to terminate this article by some reflections on the use of taking internal remedies for the solution of biliary calculi.

Remedies  
for the solu-  
tion of bili-  
ary calculi.

Various medicines have been proposed to bring about their solution in the animal body; such as soap, a mixture of oil of turpentine and ether, &c.; without considering the decomposition which substances undergo when taken into the system, which prevents them from preserving their chemical action on the calculi, when out of the body; but it is an important and curious fact, that in the gall bladder of the ox no calculi are found, except after dry seasons, and from a want of fresh forage; and that during the spring and summer, when this animal is provided with plenty of green and succulent vegetables, they disappear. The butchers are well acquainted with this circumstance; they know it is from the month of November to March that these stones exist, and at this last epoch no more are to be found. Fourcroy is of opinion that this fact is sufficient to show the power of the soapy juices of plants in dissolving these calculi. The analysis of these concretions in the gall bladders of the ox and the sheep have not as yet been compared with the human, although they sometimes are found in large quantities, and the only use made of them has been in painting.

None found  
in the ox,  
except in  
dry seasons.

*Calculus hepaticus.* The bile, in a state of disease, not only gives rise to concretions which are found in the gall-bladder, but to others that occupy the interior of the

biliary vessels of the liver ; and although these are far from being uncommon, chemistry as yet has not attended to them. These hepatic concretions are hard and solid, and perhaps on analysis may be found to resemble gall-stones in their composition.

Baillie's Morbid Anatomy. p. 156, 192. — Gren's Versuche in Gott. S. Dieterich Diss. contin. duas als. circa Calculos in Cyst. hum. inventos. Hall. 1788. — Haller's Physiol. — Hen. Fried. Delius de Colelithis Observationes et Experimenta. Erlang. 1782. — Hildebrandt's Anfangsgrunde, &c. — H. F. Teichmeyer auct. et resp. W. H. A. Storchlein de Calculis Biliariis. Jen. 1742. — Gren's Handbuch. — Hermbsstadt's Physisch. Chemisch. Versuch. & Beobachtung. — Encyclop. Méthod. tom. 2. Chimie. p. 569. — Analyse d'une Pierre retirée de la Vésicule du Fiel, par. M. Gren. An. de Ch. tom. 5. p. 186.

## EXCREMENTS.

WHATEVER is separated or excreted from the blood as useless, as well as the remnants of those substances, both animal and vegetable, which after having undergone the process of digestion, and supplied the body with nourishment, are only retained until there is an opportunity or necessity for evacuating them, may be called excrements.

These are found either in a fluid or solid state. The first comprehend the urine and sweat; the second, the feces.

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### URINE.

THIS fluid is an aqueous pellucid excretion, separated by the kidneys from the blood of animals; it contains in solution several neutral salts, and some animal extractive matter, and is perhaps the most variable fluid of any in the animal body. It differs from all the animal fluids, by the presence of a peculiar acid, by some called the lithic, by others the uric acid, from its forming the basis of some of the calculi of the bladder and kidneys; and it is also remarkable for containing a very large quantity of disengaged phosphoric acid, the phosphates of soda, ammonia, and lime; but perhaps of all its contents, the most curious is that lately found in it by Fourcroy, called ureë. Such are the principal matters contained in this excrement, the perfect analysis of which is not perhaps at present attained.

Differs from  
other ani-  
mal fluids

Ancient  
opinions of  
it.

At the time of Pliny, the contents of this fluid had not been investigated, and even but few observations had been made on it's natural, spontaneous, and external changes. The ancients had, however, made some few remarks respecting it, both in a healthy and diseased state; thus they inform us, if the morning urine is white and clear, and the next after it higher coloured and inclining to a yellow, they conclude from the first, decoction was commenced, and from the second, that digestion was perfect and completed. A red urine they considered a bad sign, but a black one the worst of all. Greenish urine betokened an obstruction of some of the viscera, and a heavy white sediment was a sign of some disease of the joints, or principal parts; if red, the blood was disordered; urine that contained matter resembling bran, or had a black cloudy appearance, foreboded danger, but if it's contents were thick and fetid, it was considered as mortal. From this it appears, how little was known of this excretion at the time of Pliny, except what was exposed to the most common observation; and even in this respect they were not fortunate in their remarks. Some ridiculous remedies were likewise ascribed to it, which, in some countries, common sense has not yet got the better of.

Moderns.

We need not be surprised at the ignorance of the ancients respecting the knowledge of the contents of this fluid, when we consider how small has been the progress of inquiry, and how imperfectly they have been examined, even in modern days. A number of writers, such as Van Helmont, Henckel, Stahl, Binninger, Boerhaave, Margraaf, Willis, Pott, and Langrish, had made us acquainted with some of the products obtained from it by distillation, and exposure to different degrees of heat; but the method of examining this excrementitious fluid by reagents was reserved for the present period; and it



is to Rouelle, Proust, Scheele, Halle, Brugnatelli, Berthollet, Cruickshank, and more particularly to Fourcroy and Vauquelin, that we are indebted for a more exact analysis and more extensive observations on the subject.

Three species of urine have at present, however, only been submitted to chemical analysis, viz. the human, that of the horse, and of the cow, to which Rouelle has added a very few remarks on that of the camel; but as the first has been more particularly the object of inquiry, and as its importance far exceeds any thing to be derived from the others, it will form the principal part of this article.

Fresh human urine, of a healthy adult person, is a perfectly transparent aqueous fluid, of an amber or vinous yellow colour; its smell is not disagreeable; for when first voided it has a great resemblance to that of violet powder, by which it is easily distinguished from all other fresh animal substances. This aroma, however, only continues whilst the urine remains warm; it often flies off in a few seconds, and the urine become cool, is succeeded by another, which is the true urinous smell. To the taste it is saline and unpleasant.

A variety of circumstances however makes it differ from this standard, and the difference is still greater when compared to that of quadrupeds.

1. The age of the person from whom it is taken. In the fetus, it is without smell, little or no taste, and almost perfectly aqueous. In childhood, the urine approaches nearer to that taken from the adult, and in old age, it is very sharp or acid, of a disagreeable smell, and very high coloured.

2. Whatever tends to increase or decrease the fluids of the body. Thus, a large quantity of cool drink, the cold of winter, repose, produce a pale aqueous urine in large quantity, having little odour or taste; on the contrary,

a full meal of flesh meat, spirituous liquors, exercise, or whatever increases perspiration, as the heat of the summer, tend to make it high coloured, in small quantity, more saline, and to give it more odour of a disagreeable kind.

3. Affections of the mind. Thus, fear, and nervous weakness, as it is called, produce a pale inodorous urine, in large quantity, whilst vigour and strength, the contrary effect.

4. Certain kinds of diet give it a peculiar flavour, odour, and colour. Thus, asparagus, olives, garlick, onions, broom, endive, artichokes, horse-radish, and vegetables of other kinds that contain a strong essential oil, are said to communicate to urine their own peculiar disagreeable smell; whilst turpentine perfumes it with the odour of violets. Similar effects are mentioned by Galen and Dioscorides, who informs us, that the ancient physicians remarked, that the use of certain roots which they administered to their patients communicated a colour to their urine and excrements, and this observation has been repeated by Cardan, Thurneisser, Porta, Caster, Durantes, and others.

Macquer informs us, he has known persons accustomed to the headach and bad digestion, whose urine retained the most evident odour of the food, such as coffee, roots of various sorts, fruits, pulse, and even of soups and broths, particularly when made of the indigestible kind of meat, and in such urines he constantly found an acid immediately after evacuation. According to Plenck, an infusion of tea or of cassia fistula gives the urine a greenish colour; the fruit of the opuntia a red, and the rhubarb, a yellow colour. In the herbivorous animals it is found to be more or less fetid; in the carnivorous, sharp and acid, whilst some have pe-

cular odours, as those of the cat, the fitchet, the tiger, &c.

Urine from it's putting on several appearances in the same person when evacuated at different times has been called by physicians under different titles. When evacuated an hour or two after taking in food, it is commonly very aqueous, and authors give it the name of *crude urine*; whilst that in the morning, which is high coloured, somewhat acid, and thicker, from the more aqueous parts having been reabsorbed, has the name of *urine of concoction*, from digestion having been supposed to be over.

Division of  
it into crude  
and concocted.

The specific gravity of healthy urine, according to Cruickshank, varies from 1005 to 1033, distilled water being at 1000; but the substances which form it's contents vary so much in their proportions, even in the same person, that it is extremely difficult to fix upon what may be considered as a standard of the specific gravity of healthy urine.

Specific  
gravity.

If fresh healthy urine be left to repose in the open air; the changes it undergoes have been divided by Halle into four periods.

It's changes  
on exposure  
to the air.

1. The first takes it's rise with that of the *peculiar urinous smell*, which is perceived a few hours after having been voided. Scarcely is the urine cold, before a turbidness appears, which is very slight, and coalescing into a cloud, sinks to the bottom. The urine is then clear again. This deposit is turbid, semitransparent, whitish, and resembles a very white jelly, of which it has all the properties, whilst Seguin affirms, that healthy urine contains no gelatin. This gelatinous deposit is only found in urine of decoction. In a day or two a second deposit takes place, which is saline: there is no apparent turbidness, but there arises a more or less thick pellicle on the surface, whilst the internal sides of the glass

1. Urinous  
period.

become more or less coated with a granular and crystallized rind, sometimes of a whitish, yellowish, or of a red brick colour; at other times this variety of colour is observed in the same urine. In the last case, the red crystals being greater and more heavy than the rest, are the first to fall down. Sometimes these two deposits take place at the same time, but only, as Halle is of opinion, when in a diseased state. By edulcoration this red part is deprived of its colour. The pellicle only appears to differ from the rind by the mucus that unites its particles. Sometimes the pellicle exhibits the colours of the rainbow, and is extremely thin and oily. They are both sandy to the touch, saline to the taste, and somewhat earthy.

2. Sour period.

2. Whilst the urinous smell increases, the urine becomes darker coloured, and the second period commences by a *sour smell*, resembling sour broth, or the caseous part of milk when turned. This sour smell does not take place in every urine, but is more peculiar to crude: in some it is scarcely to be observed, in others, it will continue two or three or more days, and it rarely takes place before the third day. During this period, a white greenish mould arises on the surface of the pellicle, and the larger the quantity of mucus, the sooner it is perceived: it resembles that on the juices of vegetables, and solutions of animal jelly, and it takes place, although the vessel be hermetically sealed.

3. Alkaline period.

3. The urine being now of a red colour, the third period takes place by an evolution of *alkali*, producing the smell of ammonia. There is a turbidness at the same time, and a number of large and small flocks in it which cause a third deposit, of an opaque, white, smooth matter, resembling marrow to the touch, and of an earthy rather than saline taste: when this alkaline smell is very strong, the urine becomes clear again, but grows darker.

This ammoniacal smell sometimes immediately succeeds the sour smell; at other times, there is an interval, when the last is only perceptible; and at other times, when there is no sour smell, it is very evident on the third, and even on the second day, but often not until the fifteenth or twentieth, or even later. It immediately destroys the mould. During this stage the urine effervesces strongly with acid.

4. The urinous smell, which has been more or less perceived in conjunction with the alkaline or ammoniacal, is now destroyed along with it, by the fourth or *putrid period*. This is known by a nauseous, cadaverous smell, the gelatinous parts of the sediment become decomposed, and are converted into a dirty gray, clotted mass, which ends with the destruction of all the properties of the urine. When this putrid stench has ceased, the rest is perfectly inodorous, the putrefactive process being entirely over. It may be observed, that during these periods, the colour of the urine becomes changed, the principal varieties of which are, a gold yellow, brown yellow, reddish brown, red and dark brown, whilst the taste grows more sharp and penetrating. We are informed by Rouelle and Halle, that crude urine is not subject to the putrefactive stage.

Having examined the changes urine undergoes in its smell, colour, and depositions when in a healthy state, we are enabled by the observations of Brugnatelli to give some account of the colours and properties of the sediment of urine in a state of disease. The appearances the sediment puts on in different diseases are various; sometimes it appears in the form of bran, or fine sand; at other times it resembles threads which have been taken for worms; sometimes it appears in the form of a thick cloud, and at other times like pus. In

*Sediment of  
urine exam-  
ined by  
Brugnatelli.*



healthy people, the colour of the sediment is almost always white, but in disease, it appears of various colours, such as gray, dark coloured, gold yellow, greenish yellow, red and black. The most usual colour of the sediment of diseased urine is red, sometimes of a pale brick colour, at other times so deep as to surpass the most lively coloured cinnabar. The colour of the sediment is likewise sometimes quite opposite to that of the urine. Brugnatelli has seen white, ash-coloured, greenish and rose coloured sediments in pale and yellowish urines; and ash and amber coloured sediments in reddish and deep red urine.

The colour  
accounted  
for.

This diversity of colour has not been accounted for. Most of the ancients attributed the colouring matter to the more or less changed state of the bile, and from this cause they were of opinion, the yellow, yellowish green, and the reddish coloured parts of urine arose.

Willis thought the amber colour in urine originated from the presence of a kind of liver of sulphur. According to Brugnatelli, the red coloured sediment is owing to the blood; and he supports his opinion, by asserting, that the high coloured sediment of a dropical patient produced with an alkali a lixivium sanguinis that precipitated green vitriol of a blue colour, but that this was not the case with the white and ash coloured sediments. According to Scheele, the red colour is owing to the lithic acid. Hildebrandt is of opinion, the higher or weaker colour in urine most probably depends on the greater or less quantity of carbon; and these two last opinions appear the most probable, since the red coloured urines are more saturated with saline substances than the others, and particularly with the lithic acid; and it is well known, that when urine begins to corrupt the colouring matter is the first that undergoes a change, passing through different shades until it becomes very dark

coloured, in which process the carbon acts a considerable part.

Brugnatelli having collected the sediments of diseased urine, extracted the saline particles by lixiviation with distilled water, and dried the remainder in the open air. It was white, light and brittle, showed no disposition to deliquesce, and had not the disagreeable urinous smell as before. It afforded, when rubbed with lime, no trace of volatile alkali. Cold water converted it into a viscid gluey substance, but did not dissolve it. It became however putrid in a warmish air, and burned with a smell of burnt hair to a coal. This sediment was dissolved by warm water, with the preservation of its colour. The red sediment that produced a red solution became yellowish on the addition of nitrous acid, but resumed its red colour again on adding some alkali. Some of these solutions gave marks of a disengaged acid.

The sediment of healthy urine which spontaneously separated on repose resembled that of diseased. Lime water, fixed alkali, and solution of soap dissolve a little of these sediments. Acids, as the acetous, phosphoric and vitriolic, produce little or no change on them. Smoking spirit of salt dissolved it perfectly when heated, and the nitrous acid, which acted even in the cold, raised a thick, yellowish scum, that tinged the skin yellow, and afterwards produced a beautiful scarlet colour. By distillation with nitrous acid, the acid of sugar was procured from the sediment. Such are the imperfect experiments of this chemist.

If first healthy urine be submitted to distillation not beyond a boiling heat, a mere water is obtained of a disagreeable smell, which forms the greater part of the urine. It amounts to about  $\frac{7}{8}$  of it, and is neither acid nor alkaline. The urine on continuing the evaporation, becomes browner and darker coloured, gets very turbid, and a certain quantity of an earthy looking pulverulent

Urine submitted to distillation.

matter is deposited, that has been taken for selenite, but is the phosphat of lime or earth of bones, with a small excess of acid. This salt is of difficult solubility, and is mixed with a little concrete lithic acid. On being evaporated to the consistence of a clear sirup, or cream, it is to be placed in a fresh place to cool, in order to obtain a crystallization of the saline substances. The first crystals that appear are, according to Macquer, the *microcosmic salt*, known by the names of native or essential salt of urine, fusible or phosphoric salt; it is a saline substance, in brownish prismatic crystals, composed of two salts, viz. the phosphat of ammonia, and of mineral alkali; but according to Fourcroy, the first crystals are those of *marine salt*. By repeated evaporation and crystallization, several successive products of crystals are obtained; afterward the less crystallizable salts, as Macquer informs us, which are common salt, and digestive salt of Sylvius, or febrifuge salt; the remainder is a brown, bitter, saponaceous extractive matter, which is looked upon as a sort of mother lye. The quantity of extractive matter is more variable than that of any other substance, hysterical or crude urine containing scarcely any of it, whilst that of concoction abounds with it. The most fresh urine exhales by a somewhat strong heat an ammoniacal odour, which Fourcroy thinks probably arises from the decomposition of the phosphat of ammonia. By a stronger heat, as the distillation continues, the extractive matter affords water, containing the carbonat of ammonia, a part of which is likewise formed in a concrete state; a very fetid empyreumatic oil; and on the fire being pushed as far as possible, a little phosphorus is obtained, produced from the fusible salt that could not be separated by crystallization, and an animal coal is left of difficult incineration, in which is found a little muriat of soda; hence this extractive matter appears to af-

Extractive  
matter ob-  
tained.

ford nothing more than the usual products of animal substances.

By a more exact analysis of this extractive matter of urine, Rouelle discovered that urine contains two substances in solution, which cannot be procured separately by means of fire. By treating the soft extract by spirit of wine, one portion is dissolved, whilst the other part remains untouched. He has called the first, *saponaceous matter*; the second, *extractive matter*. Examined by Rouelle.

The *first* he found to be saline, soluble in spirit of wine, and crystallizable, it is not, however, easily dried on the water bath; it is deliquescent, affords more than one half it's weight of ammonia, a little oil and muriat of ammonia. It's residue changes the sirup of violets green. The *second* is soluble in water, but not so in spirit of wine; hence it resembles the gummy and mucilaginous parts of vegetables, is easily dried on the water bath, like their extracts; it is black, less deliquescent than the former, and by dry distillation affords the same products as animal jelly. Rouelle obtained from one pint of urine, from one ounce to 1 ounce and half of extract; this urine, however, was voided after concoction; whereas the same quantity of crude urine only afforded 1, 2, or 3 drachms. He likewise found these two matters in the urines of the cow, the horse, and the camel, but the extractive matter of the human urine is in very small quantity. According to Cruickshank, 36 oz. of urine yield a residuum varying from 1 to 1 oz. and half. Saponaceous and extractive matters.

The analysis of urine by these means shows that it is composed of much water, disengaged phosphoric and lithic acids, the muriats of potash and soda, the phosphats of soda, ammonia and lime, and two peculiar extractive matters, which according to Fourcroy give this fluid it's colour. Component parts of urine.

Their proportions according to Cruickshank.

The relative proportions of the component parts of urine in a healthy state, Cruickshank is of opinion, may be nearly as follows :

	oz.	drac.	grs.
Of muriatic salts .....	0	.. 1	.. 0
phosphoric .....	0	.. 3	.. 50
lithic acid and phosphat of lime			
with excess of acid .....	0	.. 0	.. 25
animal extractive matter .....	0	.. 3	.. 40

The neutral salts, when purified by crystallization, are generally very fusible. This however, depends upon the greater or less proportion of phosphoric salts, particularly the phosphat of ammonia, on which their fusibility in a great measure arises. Sometimes instead of melting, this saline matter decrepitates when suddenly heated, owing to an excess of the muriatic salts, of which the muriat of potash is in general the most prevalent, and is easily distinguished from the muriat of soda, by it's crystallizing in some degree on cooling, and by it's affording cream of tartar on adding acid of tartar. In recent urine, this chemist found, that the ammoniacal salts bear a very small proportion, but when stale or putrid, they are, as may be expected, much more abundant. The phosphat of ammonia is the principal, although the muriat of ammonia is likewise to be met with.

*Putridurine.* Urine is very much inclined to putridity, and under certain circumstances, as in very warm weather, we are told by Macquer, that ten or twelve hours are sufficient to produce it ; if the heat be at the highest natural temperature, it will undergo this spontaneous decomposition in five or six hours, or less ; it then has a disagreeable, sinking, sharp penetrating smell, in which the smell of ammonia is very perceptible ; urine being one of those animal matters, from which this salt is extracted in the



greatest quantity during the putrid state. It now changes the sirup of violets to a green colour, and gives, by distillation on the water bath, a volatile alkaline spirit, that has been called the spirit of urine, or spiritus urinæ. It would appear that the disagreeable smell, which arises previous to the alkaline in these sudden changes of urine, proceeds from this salt; for if an acid, such as vinegar, be poured into urine which is beginning to stink, the stench is immediately destroyed together with the penetrating alkaline smell; on the contrary, if fixed alkali, or unslacked lime be mixed with the freshest urine, it immediately gives rise to the same penetrating putrid aroma.

Rouelle, in his examination of the nature and proportions of the salts in putrid urine found no evident difference from those collected from this fluid when fresh voided; however, in the saponaceous and extractive parts the change was considerable. According to Hildebrandt, foul urine does not afford so much fusible salt as fresh, since, during the putrefactive state, the ammonia is constantly escaping, leaving the phosphoric acid behind. The same takes place likewise if putrid urine be evaporated in a water bath, to the consistence of honey; in other respects, it does not differ from fresh urine.

Examined  
by Rouelle.

Urine was formerly considered as an alkaline lixivium, until it was discovered that it always contained a disengaged acid, in its healthy state, and when recent, for if it be kept any length of time, there is a production of ammonia; hence for examination it is requisite that it should be fresh voided.

Action of  
reagents on  
healthy  
urine.

Fresh, healthy urine reddens the tincture of litmus.

Acids produce no precipitation in it; the nitrous, however, causes an effervescence, and gives it a reddish colour.

Caustic vegetable and mineral alkalis, and quicklime,

when added to urine, produce an insupportable alkaline, putrid smell, by decomposing the phosphat of ammonia. If a solution of volatile alkali be dropped into it, a slight cloud is produced, which is the phosphat of lime, two grains of which may be obtained from four ounces of urine.

Method of  
Berthollet to  
find the  
quantity of  
phosphoric  
acid.

Rouelle, Macquer, and Halle, having looked upon urine when fresh as not possessing any acidity, it was considered in that light, until the more exact experiments and observations of Scheele and Berthollet proved the contrary. Scheele affirmed, that it contained not only the phosphoric but the lithic; but Berthollet proved that it was the phosphoric only, in a disengaged state, or rather combined in excess with calcareous earth, and he has given us the following method of determining the proportion of this acid existing in different urines, by

By limewater.

means of limewater and ammonia. For this purpose, a quantity of limewater is mixed with the urine, and the precipitate (from which phosphorus may be obtained) is to be collected on a filter. This precipitate arises from the union of the lime with the excess of the phosphoric acid, and consists of the phosphat of lime naturally contained in the urine, and suspended in it by excess of the phosphoric acid, and that formed by the lime superadded to this excess. Having likewise observed, that ammonia precipitates the calcareous phosphat of lime by neutralizing the excess of acid which held that salt in solution, he remarks, that the weight of this precipitate, compared with that produced by limewater, indicates the quantity of disengaged phosphoric acid contained in the urine; because, in fact, the phosphat of ammonia formed in this experiment remains dissolved, whilst the phosphat of lime produced by the limewater, being insoluble, is precipitated at the same time as the other portion of calcareous

And ammonia.

phosphat which naturally exists in the urine. According to Bonhomme, the urine of infants contains no acid ; but Weber has proved the contrary.

An infusion of tan or oak bark detects the gelatin, and the quantity of coagulum thrown down will, in general, bear a certain proportion to the extractive matter. From four ounces, Cruickshank obtained four grains of this kind of precipitate. Action of  
tan.

Corrosive muriat of mercury has no immediate effect on urine. Urine, however, decomposes many metallic solutions. Lemery distinguished by the name of the rose-coloured precipitate a magma of that colour, which is formed when the nitrous solution of mercury is poured into urine. When the nitrat of mercury in solution is added to fresh urine, it produces a rosy-coloured precipitate, which is the phosphat of mercury, arising from the decomposition of the phosphats in the urine. According to Fourcroy, this precipitate is formed partly by the muriatic acid, and partly by the phosphoric ; and Brongniart has observed, that this sometimes inflames by friction. According to Bonhomme, the nitrat of mercury has no effect on the urine of children ; but in old people, it produces a very abundant precipitate, of a gray colour, which is the phosphat of mercury ; hence he concludes, that the phosphoric acid increases in proportion to the age, and consequently in proportion to the destruction of the solids, which is operated by age. Muriat of  
mercury.  
  
Nitrat of  
mercury.

Muriat of barytes precipitates the phosphoric salts. By this method four ounces of urine produced a precipitate with it of 13 grains, which is equal, according to Cruickshank, to about 24 or 25 grains of microcosmic salt, consisting of such a mixture of the phosphats of soda and ammonia as are usually met with. This is therefore a test that may determine whether these salts are deficient or in too great quantity. Muriat of  
barytes.

Sulphat of  
iron.

Sulphat of iron has a similar effect to muriat of barytes, but as a little excess of acid might prevent the separation of the phosphat of iron, it is not so certain.

Acetite of  
lead.

Acetite of lead being decomposed by the muriatic and phosphoric salts, forms with the last an insoluble precipitate, but the muriat of lead may be dissolved by 18 or 20 times it's weight of water. This reagent, therefore, gives a ready method, according to Cruickshank, of determining their relative proportions; for if a given quantity of urine be precipitated by this substance, the precipitate dried, and digested in 20 times it's weight of distilled water, the remainder must be phosphat of lead, and the quantity taken up will indicate the proportion of muriat of lead. Four ounces of urine gave a precipitate of 31 grains, seven of which were taken up by digesting it in distilled water; the remaining 24 grains were found to be phosphat of lead, equivalent to 23 or 24 grains of microcosmic salt.

To discover  
the lithic  
acid and  
phosphat of  
lime by  
Cruick-  
shank's  
method.

As the lithic acid and phosphat of lime are generally deposited, at least in great measure, after the urine has become cool, and stood for some time, this chemist asserts, that they may be easily distinguished by dissolving them in twice their weight of nitrous acid diluted with a little water, and evaporated to dryness; the mass, when hot, will assume a beautiful deep rose or crimson colour, if the lithic acid be present, but will continue white although heated even to dryness, or have only a slight greenish tinge, when there is nothing but phosphat of lime. Their relative proportions may be ascertained by exposing the mixed mass, for some time, to a red heat in a crucible, when the lithic acid will either burn out or evaporate, leaving the phosphat in a pure state. The quantity of the first was found to vary exceedingly, but the last was in general nearly the same, the proportion being about one grain to two ounces.

And their  
relative  
proportions.

The urine may be considered both chemically and medically, as a fluid containing the saline and other soluble parts, that are not only useless in the animal machine, but which might hurt and derange it's functions, if not extricated from it; and secondly, as an evacuation, the proportion of the principles of which, by varying with the state of the body, becomes a species of measure by which the degrees or modifications of health and disease may, in some measure, be known. It is found by experience, that the disengaged acids, and the phosphat of lime it contains in particular, undergo very singular changes in diseases of the joints and bones, as in the rickets, &c. A large proportion of saccharine matter is found in the urine in diabetes; and although numerous future observations are wanting, before an exact knowledge of the effects of diseases on this fluid can be acquired, yet something may be gained, even in it's present infant state of investigation. For instance, we are informed by Berthollet, that the urine of gouty and rheumatic patients habitually contains much less phosphoric acid than healthy urine; but during the access of the gout, a larger quantity than usual (though not more than that of a strong person), and by making observations on the urine of a person very subject to that disease, he was enabled, at length, to know with certainty by the quantity of acid in it, whether or not he had an access of the disease.

Urine considered as a standard in health, and disease.

In order to distinguish the difference between healthy and diseased urine, to find out the shades in the proportions of their component parts, and to investigate the changes that have taken place, great assistance may be had from reagents.

Infusion of tan or bark, as before observed, is an excellent reagent to discover the presence of gelatin. In healthy urine, when the stomach and digestive functions



are daily exercised, it is said, that no precipitation takes place on adding this infusion; but in all gastric affections, and in those diseases where the urine is more or less charged with gelatin, it produces a greater or less abundant precipitation, and this happens in all cases where the assimilating or digestive powers are deranged or impaired, and wherever there are symptoms of indigestion. It likewise discovers the state of this fluid in what have been called nervous and spasmodic affections, at the approach of which the urine will be most generally found transparent, large in quantity, and abounding in saline, but containing scarcely any extractive matter. Similar appearances have also been observed to precede delirium in fevers. This state may be discovered by this infusion, with which it will scarcely afford any precipitate; on the contrary, Cruickshank found that the *acetite of lead* produced in these cases a very copious precipitation.

Acetite of  
lead.

Nitrous  
acid.

The nitrous acid has much the same effects as the muriatic of mercury. In some diseases, however, particularly in dropsy or anasarca, this chemist found, that the nitrous acid produced a milkiness, and in some instances a coagulation, similar to what would take place if added to the serum of blood. In dropsy, the general disease may be easily distinguished from that arising from a diseased liver, or other morbid viscus, both by this acid and the corrosive sublimate. In three cases, Cruickshank informs us, that the urine coagulated not only on the addition of this acid, but likewise by heat; and in one of them, that proved fatal in six weeks, the urine appeared to differ but very little from the serum of the blood, so remarkable was the coagulation produced by heat and acids. On the contrary, in the dropsy arising from a diseased liver or other morbid viscera, the urine does not coagulate either by nitrous acid or heat; it is usually small in quantity, high coloured, and deposits, after standing,

a considerable quantity of a pink-coloured sediment, which may be esteemed in some measure characteristic of a diseased, or rather a scirrhus liver. On examination, it was found to consist of phosphat of lime, some animal matter, and a little lithic acid; hence in morbid states of the urine, the coagulable part is detected by this acid, and even by heat.

It is now well ascertained, that the presence of sugar may be detected in the urine of diseased people, as in diabetes. Willis was one of the first who found that this fluid, in a diabetic patient, was sweet and like honey; and Dobson collected one ounce of saccharine matter from one pound of this kind of urine. Home informs us in his Chemical Lectures, that he brought this urine to ferment into a liquor similar to beer; hence he looked upon it to be of a vegetable nature, supposing no other animalized fluid capable of that fermentation.

Presence of  
sugar in  
diabetic  
urine.

For the detection of sugar in urine, even in small quantity, Cruickshank added twice the weight of nitrous acid to one of the extract obtained by evaporating some diabetic urine; he then evaporated the whole to a very small quantity, and found, when cold, that if the crystals formed in it be all of them cubes, or rhomboids, it is certain that no oxalic acid has been produced; but if slender needles or prisms be found along with them, they should be carefully separated, dried on blotting-paper, and thrown into limewater, and the precipitate, if formed, must be either from phosphoric or oxalic acid; if it has the resemblance of flocks, and subsides slowly, the phosphoric acid is the precipitant; if it has a powdery form, and subsides quickly, it must be produced by oxalic acid, for all animal substances, according to this chemist, do not yield oxalic acid; the extractive matter of healthy urine, and the pure coagulated part of the serum of the blood being exceptions.

In confirmed diabetes the urine is sweet; this chemist, in one case, collected by evaporation, from thirty-six ounces, troy weight, of urine, three ounces one drachm of saccharine extract, which, in the day, would have amounted to twenty-nine ounces. He likewise found, that this saccharine extractive matter, like honey, afforded no saccholactic acid by the nitrous acid, consequently, that it does not contain it's basis, which sufficiently distinguishes it from the saccharine part of the milk of animals, and appears to prove, that it is nothing more than vegetable sugar mixed with a greater or less proportion of animal mucilage. He found that two drachms of dryish and sweet diabetic extract, yielded with twelve drachms of the nitrous acid from forty to fifty grains of crystallized oxalic acid, which is nearly the proportion obtained from an equal quantity of common sugar, making allowance for the water and saline substances. The nitrous acid detects also a small quantity of bile during the jaundice, by rendering the urine green, but this is better detected by the muriatic acid; when therefore the urine ceases to become green on the addition of either of these acids, it may be concluded, that the obstruction to the passage of the bile into the duodenum is removed, and consequently that the yellowness of the skin, &c. will soon disappear; the sulphuric acid, in some measure, produces the same effect, but the muriatic is preferable to either of the other two.

Action of  
the muriatic  
acid.

Sulphuric  
acid.

Muriatic of  
mercury.

It has been observed, that muriatic of mercury has no effect upon recent healthy urine, but it has been found very useful in detecting the condition of urine, accompanying the acute rheumatism, inflammation of the chest, and other inflammatory diseases, immediately affording a greater or less degree of milkiness, and a whitish precipitate during the active state of the disease; when, however, the disorder takes a favourable turn, this effect

will in great measure cease, and a lateritious sediment appears. The same happens in fevers accompanied with a strong action of the vessels; but in these cases the lateritious sediment, which never fails to make its appearance at the crisis or abatement of the disease, is much more remarkable and constant, and the nitrous acid, when added to the urine before the deposition takes place, gives it a pretty deep red tinge. Likewise in gout, the termination of the paroxysms is most perfectly indicated by a copious lateritious sediment, and when this suddenly disappears, and the urine at the same time affords a precipitate with the muriat of mercury, a fresh attack or relapse may be expected. This chemist generally found this sediment to be composed of lithic acid, phosphat of lime, and some peculiar animal matter, but little soluble in water. Some have supposed it to consist entirely of lithic acid, but this generally constitutes the smallest part.

Bonhomme, who has examined the different states of <sup>Nitrat of</sup> urine by the nitrat of mercury, and particularly the difference between the urine of old people and that of those troubled with the rachitis, found that the first contained a much greater quantity of earthy deposit and saline extract than that of younger subjects; and that with respect to the second, the urine of these under this disease presented an abundant and earthy deposit, which differed in appearance from that of old people, affording no phosphat of lime; it is also greater in quantity, one pound depositing two ounces, whilst that of the first only deposited forty-five grains. The extract from that in rachitis, left by evaporation, is larger in quantity, even by a third. Hence it appears, that the solids in rickets are destroyed more rapidly than in old people, and furnish more abundant relics. Likewise the deposit that lime-water occasions in the urine in rachitis, is very inconsi-

derable, of a brown colour, gelatinous when fresh, and powdery when dried; and does not resemble the phosphat of lime in any respect. Lastly, the precipitate formed by the solution of the nitrat of mercury is very abundant, never rose-coloured in rickety urine, as in that of adults, nor gray, as in that of old people, but always white; hence has no external relation to the phosphat of mercury. This chemist looks upon it to be an oxalat of mercury. When, however, the rickets was cured, the urine became again the same as that of healthy children, and this may be the means of knowing when this disease has submitted to the art of medicine.

Acetite of  
lead.

For the acetite of lead, *vide* the effects of tan on urine, in a diseased state. From these few and imperfect observations on the action of reagents on healthy and diseased urine, it may be concluded, that the importance of the subject demands a more extensive investigation; which, by affording a more perfect collection of facts, would be capable of greatly assisting the science of medicine.

Acids supposed to exist in urine.

As several acids and salts are related by some chemists to have been discovered in healthy urine, it may be necessary to give some account of those which this fluid has been supposed to contain, and the mistakes the investigation has given rise to.

Carbonic  
acid.

It was supposed by Dr. Priestley, that recent urine contained fixed air, as he had extracted from it about one fifth of it's volume of that acid: he, however, confesses, that not only heat was necessary, but even continued for several hours. Dr. Percival has published an account in the London Medical Journal, of having nearly saturated urine with fixed air, by merely drinking a sufficient quantity of water, impregnated with this gas: but the error of these two philosophers has been proved by Morveau,



who has shown, that it was the phosphoric acid, and in a disengaged state, as discovered by Berthollet.

In 1740, Haupt affirmed, that there was a peculiar salt in urine, which he distinguished from the microcosmic, by the name of *sul mirabile perlatum*, and which in 1737 Hellot had previously found in prismatic crystals, and looked upon as selenite. Pott, who had as well as Margraaf observed, that by a strong heat, it afforded a white vapour and no phosphorus, took it for a species of vitriolic acid, somehow connected with an alkaline salt. Rouelle calls it the sel fusible à base de natron, and looks upon it to be the animal or phosphoric acid, united with natron for it's basis: this celebrated chemist has described the process of separating it from all foreign matter, in a very exact manner.

In 1781, Proust undertook it's examination, but he denied that the acid was the phosphoric, because the substance when distilled in the dry way with charcoal afforded no phosphorus. Having observed that it was decomposed by vinegar, which deprived it of it's basis, and which by repeated evaporation afforded the acetite of soda; in order to obtain that substance pure, which previously neutralized the soda, he used alcohol in order to separate the last portions of the neutral salt from the mother lye of the crystals. Having, therefore, crystallized the greater part of the acetite of soda, he poured on the mother lye eight or ten times it's weight of hot spirit of wine, agitated it strongly, until the acetous salt was dissolved, and a thick matter was collected at the bottom of the vessel in the form of a *magma*. This matter was washed in fresh hot spirit of wine, afterwards dissolved in distilled water, and afforded by spontaneous evaporation in the open air crystals, which this chemist looks upon as a body *sui generis*, and which he places amongst the simple salts, and compares to the acid of

Perlate acid. borax. This salt was afterward placed by Bergmann amongst the acids, in his Table of elective attractions, by the name of *acidum salis perlati*; and Morveau, who looks upon it not as a disengaged, free acid, because it changes the sirup of violets to a green colour, thinks, however, that an acid is present, although the method of obtaining it has not yet been discovered. He is of opinion that it performs the function of an acid, since it unites to different bases, which is sufficient to give it a place in that class; and he has described it in the Encyclopédie Méthod. by the name of the *ouretic acid*. From the experiments of Klaproth, it has now been proved, that this supposed peculiar acid is nothing else than the phosphoric, as Rouelle had already considered it, united to a little soda; and that the vinegar used by Proust only extracted a part of this soda; for if a solution of the nitrat or muriat of lime be poured into a solution of perlate salt, a precipitate of phosphat of lime immediately takes place, and then the phosphoric acid may be separated by the vitriolic acid in the manner phosphorus is made; and on the contrary, if pure phosphoric acid be saturated with soda, it forms the real perlate salt, or *acidum perlatum*.

Acide oure-  
lique. Oxalic acid. Another acid, that has been said to exist in urine, is the oxalic, or acid of sugar. Henckel had obtained small white prismatic crystals from some urine that had been kept well closed for three or four years, which have since been said to be those of the acid of sugar, although others have expressed their doubts. Brugnatelli obtained an acid from the sediment of urine, which Leonhardi looks upon as resembling the acid of sugar, but it was saturated with lime. It shot into quadrilateral white crystals, soluble in cold water, deliquesced in the air, tasted sour, and possessed all the common properties of an acid. It's solution decomposed all calcareous salts, and precipi-

sated lime water, and vitriol of iron of a white colour. It was soluble in vitriolic acid, formed with potash an orange-coloured saline mass, which after edulcoration with water gave colourless, transparent, prismatic needles in clusters, insoluble in cold and warm water, and exposed to fire left lime and alkali behind. The acid itself, likewise, after swelling in the fire, left a white lime. That from the red sediment of urine also contained some particles of iron. This acid, therefore, which so much resembles the oxalic, was united with earthy parts in the sediment, and with ammonia in the urine. There is, however, every reason to suppose, that whenever any saccharine acid has been met with in urine, it is in consequence of diseased digestion; for Scheele, who was a most accurate and experienced chemist, found no such acid in healthy urine, but he obtained by smoking acid of nitre what appeared to be the salt of benzoin, and which he supposed to be united with volatile alkali.

Acid of  
benzoin.

With respect to the vitriolic acid, selenite and vitriol of potash, as well as muriat of lime, and Glauber's salt, which Lauth thought he had found, they were only accidental; and his siliceous and argillaceous earths probably arose from the utensils he employed. The other substances, said to have been found in this fluid, are scarcely worth mentioning; Westendorf and Gunther, however, thought they had discovered a naphtha, and it was the opinion of the celebrated Bergman, that besides the different saline bodies, it contained a bilious, fat matter.

Other sub-  
stances.

There are, however, some well grounded suspicions of the presence of a peculiar substance, or rather acid in urine. We are informed by Cruickshank, that if to an ounce of extract of fresh urine the same weight of concentrated nitrous acid, diluted with an equal quantity of

Reasonable  
suspicions of  
an unknown  
acid by  
Cruick-  
shank.

water be added, an effervescence takes place with heat, and nitrous gas is disengaged; and in the liquor when cool, a number of shining scales or crystals are deposited, resembling the acid of borax, which well dried weighs from five to seven, or more drachms. Their figure appears to be flat rhomboids, smooth and greasy between the fingers, more soluble in hot than cold water, in some degree in alcohol, and although repeatedly washed with this fluid and dried, they still retain acid properties, strongly redden violets, are easily taken up by the acids of vitriol and common salt, without commotion, but effervesce with the nitrous, and form very soluble salts, the properties of which have not been sufficiently examined. Their solution in water does not precipitate limewater, nor the muriats of lime and barytes, nor the nitrats of silver or mercury, in any sensible degree, nor has it any effect on the sulphur of iron or acetite of lead; they neither contain, therefore, phosphoric or oxalic acid; when thrown on a red hot iron, they melt and evaporate into a white smoke, leaving a very small quantity of a charry residuum, by no means difficult to incinerate, but when exposed to an intense heat, they burn with a reddish flame, and a kind of detonation, somewhat similar to nitrat of ammonia; hence, says Cruickshank, it would appear that this substance is an animal acid hitherto unknown, and whose basis exists in this extracive matter.

By Dr.  
Gaertner.

Another testimony of an acid in urine is Dr. Gaertner, who has been much employed in experiments on this fluid. He found, after a very rigorous examination, that the acid of urine, which he took for the phosphoric, only resembled it in a few properties, and that it possessed others totally different from all the acids. This acid is volatile, and exposed to a strong heat is sublimed in the form of flowers; the nitric acid does not convert it; the

nitric, muriatic, and sulphuric acids, precipitate it from it's alkaline and earthy combinations, partly in the form of gas, and partly under that of a fixed acid; it forms by evaporation a scaly salt, which is not changed on exposure to the air, and which expands the odour of the gaseous acid. Dr. Gaertner asks, whether it may not hold the medium between the benzoic and lithic acids?

The existence of the phosphoric acid, whether combined or free in urine, was unknown to the ancients; a few observations, indeed, on the effects of this fluid had been made, but they had no idea that it was owing to any particular acid, and it was not even suspected to exist until the discovery of the essential salt of urine, and of phosphorus, in which it exists in a state of combination, (*vide* phosphoric acid). The discovery of it's being present in urine, in a disengaged state, is much more recent. Rouelle had observed, that at a certain time preceding putrefaction, this fluid changed the sirup of violets to a red, and Macquer proved that the urine of those with bad digestion reddened an infusion of litmus; but Berthollet, extending his researches much farther, found that the urine of people who enjoy the best health has the same property; and that it depends upon the presence of the phosphoric acid in a disengaged state. To be convinced of this, when lime water is poured into recent urine a white powder is deposited, which is the phosphat of lime. Berthollet is of opinion, that this acid becomes afterward saturated with the volatile alkali, formed by putrefaction, or the action of heat, which Morveau thinks may be admitted, without excluding the idea of a portion of it having been previously saturated with the same basis. Berthollet also remarks, that when lime water is poured into recent urine, it not only takes hold of the uncombined acid, but also

Disengaged  
phosphoric  
acid in  
urine



of that portion united to an alkaline basis, from it's greater affinity with lime.

Microcosmic salt.

The crystallized mass obtained on the evaporation of urine, forms a salt which was called native phosphat, or phosphoric salt of urine, or microcosmic salt; it has likewise gone by the name of fusible salt, from it's melting on exposure to heat. According to Spielmann, Schockwitz is the first who described this salt, in a thesis at Halle, in 1699; but Pott attempts to prove, it was discovered before, and quotes Raymond Lully, Isaac Holland, and Van Helmont for this purpose, but he allows, the traces of it's being mentioned in their works are very obscure; it is, however, very extraordinary, that chemists had been so tardy in the examination of it, since it appears spontaneously in the residuum of urine, after evaporation.

When discovered.

Obtained from fresh urine by Boerhaave.

Boerhaave, in describing the process of obtaining the microcosmic salt, has as well as Henckel recommended the urine of healthy people; others from infants, or from those whose only beverage has been beer or wine; and some have even advised it to be taken during the months of March, April, or May. It is very possible that urine is more or less charged with this salt, according to the nature and quantity of the aliments; and it is very evident that the derangement of the animal functions must, to a certain point, influence the nature of the excretions; but in general, as the celebrated Pott has observed, there is no occasion to be so scrupulous, as all urines without distinction afford a sufficient quantity of this salt. There was, however, another difference amongst chemists, and Haupt and Margraaf affirmed against Boerhaave and Henckel, that putrid urine was the best, and this was adopted by Vencel, Villermoz, and several others. It may

From putrid urine by Margraaf.

be added, that Margraaf abridged the length of the operation; for after evaporation, instead of one year's repose,

in order to separate the crystals, as Boerhaave had done, Margraaf demanded only one month, and Schloffer reduced it to a single night.

The labours of Rouelle jun. and Proust threw new light on this subject, and instead of surmises, reduced it to principles. Rouelle saw very well, that whether by putrefaction, or the heat of ebullition, a quantity of volatile alkali was disengaged from the urine, which leaving the acid without a basis, retarded and diminished the production of crystals; hence to avoid that inconvenience, and more completely to separate the common salt, he advises the urine to be evaporated to the consistence of sirup, to be filtered when hot through linen, adding at the same time a necessary quantity of water to prevent crystallization. The small quantity of phosphoric salt remaining on the filter with the common salt and selenite, is easily recovered by cold water, and then is added to the filtered liquor. This liquor is then gently evaporated by heat if necessary, and when cool volatile alkali is added, and the crystals are obtained in abundance, or it is left to evaporate in the open air, which is more difficult. Whatever process is used, the salt of the first crystallization is never pure; it is soiled by the extractive matter, and contains always a little common salt, and *sal perlatum*, before mentioned.

Since the greater part of the salt evaporates by heat, the Duke de Chaulnes has recommended a process which purifies it with the least possible loss; it consists in dissolving, filtering and cooling the solution in well closed vessels, by which means the real phosphoric salt is obtained crystallized in very flat rhomboidal quadrilateral prisms, and is now called by chemists the phosphat of ammonia, and above these crystals is the perlate salt, or phosphat of soda, in cubes, or rather long square tablets, and very different from the other.

The process  
improved  
by Rouelle.

By de  
Chaulnes.

Although these two salts were supposed to be pure, it is since found that each is a triple salt, the first formed of a large proportion of phosphat of ammonia, and a little phosphat of soda, and the second in a contrary proportion.

Triple salt  
of ammonia.

The triple phosphat of ammonia is a salt the crystals of which, according to Rome de l'Isle, are in the form of tetraedral rhomboidal prisms, very compressed, often truncated in their length, and on their angles, from which hexagonal prisms arise resembling Rochelle salt. Longitudinal segments of these prisms are not uncommon. The side placed on the capsule is larger and more smooth than the others, somewhat rhomboidal, and easily known by two diagonal lines which cut each other in the centre. According to Fourcroy, the tetraedral and octoedral forms are only found when this salt contains a good deal of muriat and phosphat of soda. The muriat appears more particularly to modify it to the octoedral form, since on dissolving the first salt in urine, and exposing it to the sun, in a few days regular octoedral crystals are obtained.

The flavour of this triple salt is at first cool, then urinous, bitter, and pungent. Exposed to the blowpipe, it swells, emits an odour of ammonia, and melts into a deliquescent vitreous globule.

Distilled in a retort, a very penetrating and caustic ammonia is disengaged, the residue is a very fixed and fusible transparent glass that attacks the retort. Margraaf says, it presents the characters of an acid: Rouelle asserts it is deliquescent: Morveau, on the contrary, believes, that by a strong heat it may be reduced to a fixed vitrified state.

According to several modern chemists, this glass, which still retains a portion of phosphat of soda, is always opaque, or easily susceptible of becoming so; it is only the pure artificial phosphat of ammonia that affords a transparent glass, like the phosphoric acid itself.

This salt changes very little on exposure to air. It is very soluble in water, requiring only five or six parts of cold water; at a heat of  $60^{\circ}$ , a part of it is decomposed by this fluid, and a portion of its acid even is volatilized. It is decomposed by the caustic fixed alkalis and lime, and the ammonia is separated; if limewater be added to its solution, a white precipitate of phosphat of lime is obtained; the alkaline and earthy carbonat also decompose it, and the ammonia is separated in the form of a carbonat. It causes the fusion of flint, alumine, barytes, magnesia, and lime, but these vitreous compositions belong to the phosphoric acid, and the phosphat of soda, since the ammonia escapes before the fusion takes place. When treated with charcoal in close vessels, phosphorus is obtained. With respect to the action of the acids, metals, and their oxides on this salt, it depends on the attraction the phosphoric acid has for the alkaline bases of the salt, these metals, and their oxides.

The triple salt of soda had, as before observed, been taken for an acid, by Bergman, called the perlat; by Morveau, the ouretic acid, till Klaproth proved the acid in it to be the phosphoric.

Triple salt  
of soda, or  
perlate salt.

The first chemists who examined it found, that the great difference between it and the preceding salt consisted in affording no phosphorus when mixed with charcoal; but according to Rouelle, who best knew its properties, the crystals of the perlate salt, or triple salt of soda, are flat, irregular, long tetradral prisms, one of the extremities of which is diedral, and composed of two rhomboids cut transversely, and the other adheres to the basis. The four sides of the solid are two pentagons, irregular, alternate, and two lengthened rhomboids.

Exposed in a crucible, it melts into a white opakeness; heated in a retort, it affords a phlegm slightly ammoniacal, and the residue is a glass much more opaque than that



from the triple phosphat of ammonia. This salt, when exposed to the air, effervesces, and falls into a powder. It is soluble in distilled water, which changes the sirup of violets green, and it may be crystallized on evaporation. It is decomposed by nitrat of lime; the precipitate is phosphat of lime, and the water affords nitrat of soda. It is also decomposed by the nitrat of mercury. Also by lime, for if limewater be poured into a solution of this salt, a precipitate is formed, and the soda remains pure and caustic in solution. Likewise by the acids. It is not decomposed by charcoal like the phosphat of ammonia, and it is equally curious that the phosphoric acid, when added in excess to the phosphat of soda, leaves it the property of changing the sirup of violets green. Lastly, this phosphat of soda always contains a little phosphat of ammonia, and this last always plays it's part in every combination it is made to undergo.

Remarks of  
Fourcroy.

Hence it appears, that the salt obtained by the cooling and repose of urine, when evaporated, and which from it's melting by heat was originally called fusible salt, the essential salt of urine, or microcosmic salt, is principally composed of these two triple salts, which only differ from each other in the proportions of the two alkalis; but as it would be trespassing too much on the design of this work to enter into a more minute detail of them, it will be necessary to conclude with a few observations of Fourcroy. He found, after various trials, that it was impossible completely to separate them, so intimate is their combination. He found, that after keeping a few pounds of this salt of the first crystallization, for about six years, in a well covered glass bottle, a very sensible musk or amber odour had succeeded it's peculiar fœtid odour; that this fusible salt, which effloresces in the air, always greens violet paper; and this effect is produced whether the crystals be obtained at the beginning or end of the



operation, *i. e.* whether they be phosphat of soda and of ammonia, or phosphat of soda almost pure. This is the more singular, since it is proved that urine on evaporation loses some of it's ammonia, without losing the phosphoric acid in proportion, and in consequence becomes acid; yet the salt obtained greens instead of reddens the blue of the violet. Another not less remarkable circumstance is, that this salt exposed a long time to the air entirely passes to the state of phosphat of soda, which always greens violet paper. The phosphat of ammonia, therefore, appears to be completely volatilized by the simple heat of the atmosphere, as Rouelle and Chaulnes had already observed. The different triple salts obtained from it all afford ammonia by lime. To find the exact proportions in this salt, Fourcroy dissolved it in cold water, and precipitated it by limewater; the precipitate collected, dried, and weighed, then saturated with muriatic acid, and evaporated, and the weights of the muriats of soda and ammonia obtained, gave the proportions of the phosphats of soda and ammonia. He found that one hundred grains of this fusible salt of urine afforded,

grains,

Of ammonia	..... 19
soda	..... 24
phosphoric acid	.... 32
water	..... 25

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100

Besides the combinations of ammonia and soda with phosphoric acid in urine, it likewise contains the muriat of soda, the phosphat of lime, and the lithic acid; for which two last, *vide* Bones and Acids.

According to Leibnitz, phosphorus was first procured from urine by Brandt, about the year 1667, as he was endeavouring to obtain a liquor from this fluid, in order

Phosphorus  
obtained  
from urine.

to convert silver into gold. He made this discovery a little time after Baudoin had found the phosphoric property of the Bolognian stone. Brandt communicated this discovery to Kraft and Kunckel, who associated together in order to find out the secret; but the one having acquired it for himself alone, Kunckel, who knew only that it was procured from urine, made the attempt and succeeded. This success not being the effect of chance, chemists have thought proper to give him the honour of the discovery of phosphorus, by naming it *Kunckel's phosphorus*. Kraft either told Boyle the secret, as Stahl affirms, or Morveau thinks, gave him a specimen of the production. Kunckel, and a German chemist, Hatwitz, who worked in the laboratory of this English philosopher, were a long time the only persons who prepared phosphorus in quantity, and from it's having been sold by the last to most of the philosophers of Europe, it received the name

In England. of *English phosphorus*. Although from 1680, to the beginning of the present century, a great number of receipts for making phosphorus had appeared, and amongst others, those of Boyle, Kraft, Brandt, Homberg, Teichmeyer, Hoffmann, Albinus, and even Kunckel, who had published his own process in a work entitled, *The Chemical Laboratory*, yet the process was not generally

France. known; and the first time it was repeated in France, was by a foreigner, in 1737, who performed it in the Royal Garden, in the presence of four chemists of the academy,

Process by Hellot. Hellot, Dufay, Geoffroy, and Duhamel, and the process succeeded. Hellot afterward described it in a memoir for the year 1737 of that society. This operation consists in evaporating five or six barrels of urine until it becomes grumous, black, hard, and shining; the residuum calcined in an iron pot, the bottom of which is made red hot, until there is no more smoke, and there arises the odour of peach flowers. It is then lixiviated with twice the quantity of warm water, and then exsicc-

eated after decantation. Three pounds of this are to be mixed with one and half of sand, and four or five ounces of beech charcoal, then moistened with half a pound of water, and put into a Hessian retort. It is essayed first by a red heat in a crucible; for when a violet coloured flame and a garlic smell arise, it will produce phosphorus. The retort is then placed in a furnace, and a large receiver is fitted to it, one third part of which is filled with water. This receiver must have a hole pierced through it, which Hellot looks upon as very necessary, in order to succeed. Three or four days after this preparation, a gentle heat is applied to dry the furnace and lutes; it is then increased to the utmost violence, and kept up for fifteen or twenty hours. The phosphorus only comes over fourteen hours after the beginning of the operation, which lasts for twenty-four hours; a large quantity of carbonat of ammonia arises, which is in part dissolved by the water. The volatile or aciform phosphorus arises first in luminous vapours, then the real part runs like an oil or melted wax. When no more comes over, it is left to cool for two days, the lute is taken off, and water is added to that in the receiver to detach the phosphorus adhering to it's sides. It is then melted in boiling water, cut into small pieces, which are introduced into glass tunnels, (matrass necks) and plunged into boiling water. The phosphorus melts, purifies, and becomes transparent from the separation of a blackish matter which rises above it. It is then put into cold water, in which it becomes hard, and it is extracted from the tunnels by pushing it with a stick. Such is the process described by Hellot, (*vide* Phosphoric Acid). According to Macquer, however, the first time that Rouelle tried this method, it did not succeed from the failure of the retort, but he after-ward repeated the operation in his chemical lectures,

and from it's length and labour, he was the only chemist who repeated it.

Improved  
by Margraaf.

In 1743, Margraaf published a method of extracting it more easily. The urine is first reduced to the consistence of honey, and nearly three barrels are necessary for one ounce of phosphorus; during the evaporation a few ounces of tallow are cast into the vessel to stop the rising up occasioned by the heat. Ten pounds of this extract are then mixed with some muriat of lead (*plomb corné*) the residuum of the distillation of 4lbs. of minium and 2lbs. of ammoniacal muriat, and half a pound of pulverized charcoal is added. This is then to be stirred in an iron pot until it is reduced to a black powder, then distilled in a retort by a gradual heat to extract the carbonat of ammonia, the fetid oil and the muriat of ammonia, taking care not to push the heat until the retort is somewhat red, and the black and fusible residue is the matter from which the phosphorus is extracted. It is essayed by casting a little of it upon red hot coals; if there arise a blue flame, and a garlic smell, it is well prepared. A Hessian retort is then filled with it even to  $\frac{3}{4}$ , is placed in a furnace with a receiver adapted, having a hole in it, and half filled with water, well luted, and here it is left to dry a day or two, and then the distillation is begun by a gradual heat. This lasts from six to nine hours, according to the quantity of matter. The phosphorus is then rectified by a very gentle distillation, in a glass retort, with a receiver half filled with water. This process was practised with success by the academicians of Dijon, in their first course of lectures, in 1776, but the noisome odour which arose on mixing the muriat of lead with the extract of urine would have prevented it's being continued, and although almost all the chemists were obliged to make use of this method, the discovery of procuring it from other materials rendered it unnecessary.

It appears that the process of Margraaf only differs from that of Hellot by the addition of muriat of lead, and by the operation being performed at twice, but the most curious part is, that this Prussian chemist has determined what the substance contained in urine is, that serves to form the phosphorus. On distilling a mixture of *fusible salt* and charcoal, he obtained a beautiful phosphorus, and he observed that the urine from which this salt was extracted afforded scarcely any of this combustible substance; hence it must be a constituent part of this salt that contributes to the formation of phosphorus, and this substance is easily obtained by distilling two parts of glass obtained from this salt decomposed in a crucible or retort, with one part of powdered charcoal. This operation requires less time and heat than those already described, since according to Proust, the phosphorus runs in a quarter of an hour; but although this process is the best to extract phosphorus from urine, there are several observations to be made. 1. Very little phosphorus is obtained; for the vitreous residue of the decomposition of ammoniacal phosphat by heat is not pure phosphoric acid, but combined with soda, which is not decomposable by charcoal; hence one ounce only affords one drachm of phosphorus at most. 2. When the fusible salt is prepared by evaporation, and cooling in large quantity, a great deal of phosphat of soda is mixed with it, which affords no phosphorus. From these two remarks, therefore, it appears why so little phosphorus is obtained on distilling fusible salt with charcoal; and perhaps the same salt entire, distilled with coal and muriat of lead, may afford more, since this last appears to have the property of decomposing the phosphat of soda; and we are informed by Morveau, that Black made the experiment; for being assured that the salt formed of phosphoric acid and soda was not decomposed by charcoal assisted by heat,

The difference between them.



he attempted this decomposition by the muriat of lead, and he succeeded in obtaining phosphorus, which proves the advantage of Margraaf's method. The disagreeable stench arising from the evaporation of urine, and the labour required in the process for procuring this combustible substance, were however great reasons for discontinuing the practice, and the method of extracting it from bones, as discovered by Gahn and Scheele, which is easy and pleasant, has entirely put an end to the procuring of it from this fluid.

Fourcroy  
and Vau-  
quelin dis-  
cover a new  
substance,  
and call it  
urée.

Having thus given some account of the experiments that have been made on urine, and of the matters which have been supposed to exist in it, or are considered as forming part of it's constituent principles, it remains to detail the analysis and observations of Fourcroy and Vauquelin, who have found a peculiar matter in this fluid to which they give the name of *urée*. It appears this matter forms the greater portion of the composition of this fluid; to it is owing it's odour, flavour, and the changes it undergoes; and it is by reason of this, that urine differs from all other animal fluids, since it characterizes it's nature, and without it this fluid would no longer be what it really is.

Which had  
been slightly  
observed be-  
fore.

With respect to the discovery of this peculiar substance, Rouelle the younger is the first that has given any precise idea of it. Indeed the generality of those who have examined this fluid chemically seem to have had some little notion of it, but they did not take sufficient notice so as to form any knowledge of it's properties. It is undoubtedly this matter, the tinging quality of which, and property of giving different shades of colour to this excrementitious liquid according to it's quantity, Bellini had observed; but being entirely taken up with the coloration of urine, he never thought of examining the nature of the colouring matter. Boerhaave,

By Bellini.

Boerhaave.

speaking of a sort of sapa, or extract of urine, compares it to a kind of honey, and describes it as bitter, sharp, and not alkaline. Margraaf, in describing the salt of urine that affords phosphorus on distillation, says, that a fat matter, or *fæces pingues*, is deposited with it, which affords a spirit of salt and some oil by distillation. Pott, Pott. Schlosser, Haupt, and others, likewise perceived it; and it is impossible for it to have entirely escaped the notice of chemists, who have examined urines by different means, although they have said nothing in particular of it.

Rouelle is the first who has mentioned it more explicitly; and having discovered a few of it's characters, described it by a particular name, twenty-five years ago, evidently with an intention of distinguishing it as a distinct substance. This is the *saponaceous matter* already mentioned. He informs us, it is of a deep brown colour, has a disagreeable odour, is of an oily consistence, is crystallizable, but not susceptible of exsiccation, is acted upon by heat like a mucous body, extremely deliquescent, containing the muriatic acid in a state of combination; affording by analysis more than half it's weight of volatile alkali, a little oil, and some sal ammoniac, but that the residuum contains nothing alkaline. From this account, it appears, that Rouelle had well characterized a peculiar substance, which he was desirous particularly to distinguish from extracts, and which is the *urée* of Fourcroy and Vauquelin. Rouelle regarded this soapy matter of urine as the *nutritious matter of vegetables*, changed in it's nature by digestion and circulation, and by new combinations it had formed on passing into the animal economy, with which it became assimilated; and he observed, that with the extractive matter, it was the most changeable of any of the component parts of the urine.

Rouelle, the first who has any ways characterized it.

Nearly forgotten since the time of Rouelle, it appears to have escaped the attention of chemists, until Scheele, in his memoir on the vesical calculus, mentions it without describing it, by the name of *oily extractive* matter. Cruickshank has, however, given an account of some of it's properties, and has distinguished it from all others which have been as yet related by two of it's most characteristic and striking qualities; for, in the work of Rollo, on diabetes, this chemist informs us, that the animal extractive matter of urine affords, on distillation, at first water impregnated with carbonat of ammonia, the same salt in a concrete state, then a fetid empyreumatic oil, afterward a little phosphorus, and an animal coal is left of difficult incineration. Treated with twice or thrice it's weight of nitrous acid, it affords half it's weight of flat, rhomboidal, and shining scales, resembling the acid of borax. By exposure to a gentle heat, the scales evaporate in a white smoke; to a strong heat, they burn with a red flame, and a kind of detonation resembling that from nitrat of ammonia.

The method of separating this peculiar urinary matter is by evaporation. The urine of an adult person, voided seven or eight hours after a meal, is to be evaporated in a glass vessel by a gentle heat, until it has acquired the consistence of a thick sirup. It is then of a deep brown, has a fetid odour, and it's nature is evidently ammoniacal. During it's cooling, the whole mass takes the form of granular crystals, which are a mixture of all the salts with the urée. To obtain this, four times it's weight of alcohol is to be poured upon it at several times, and exposed to a slight heat. The greater part is now seen to dissolve, and give an obscure brown colour to the liquor, and there remains a saline matter nearly white, which Rouelle advised to obtain in this manner, and from

it's solubility in alcohol, he named that which this menstruum took up, *saponaceous matter*.

This brown alcoholic solution is then to be poured into a glass retort, exposed to a sand heat, and a fetid alcohol is obtained, charged with carbonat of ammonia, which effervesces with acids, and which, on their addition, becomes of a rose colour, from dragging with it a certain proportion of urée. This distillation is continued until the ebullition is pretty strong, and until the liquor acquires a sirupy consistence. The alcohol being distilled, the whole matter on cooling crystallizes in the form of intersected subquadrangular plates, the edges of which appear to be cut; their colour is of a shining yellowish white, and even brownish in many points. This crystalline mass exhales the odour of fetid urine, with a garlick smell, it's taste is strong, pungent, and resembles that from ammoniacal salts; it deliquesces, and is converted by degrees into a thick brown liquid. It's odour in particular is extremely characteristic; it's stench is insupportable, resembling that of arsenical sulfures. Besides the disgust it causes, these chemists suspect it's capability of producing disease, for on being employed several hours upon it, they contracted a headach, and were indisposed. It's properties.

On detaching urée from the vessels in it's crystalline form, it resembles a granular paste; is difficult to cut; viscous, tenacious; internally, very solid; externally, softer, like a thick honey, to which Rouelle compared it, as Boerhaave already had before. It dissolves so rapidly in water, that it is only necessary to pour a small quantity into the vessel that contains it, immediately to detach it, and on the slightest agitation, it becomes a thick brown liquid. During this solution, a very sensible coldness is produced.



Ureè is somewhat less soluble in alcohol than in water; it's alcoholic solution affords crystals much more easily on cooling, than that procured by water.

Forms a curious salt with nitric acid.

On mixing it's aqueous solution, somewhat concentrated, with nitric acid, crystalline plates are instantly deposited, which are white, shining, and pearly. Urine, when exsiccated, presents the same phenomenon: it seems that the ureè forms with the acid a sort of salt that is little soluble, and very crystallizable. This property is one of the most singular and characteristic of this matter. The other acids do not produce the same effect. The muriatic precipitates it from it's alcoholic solution in the form of white flocks.

It's aqueous solution assumes different colours.

Precipitates the nitrat of lead.

It's solution in water is of a brown colour when this fluid is in small quantity, but it is made to pass through all the shades of orange, yellow, and lemon colours, by the quantity of mēstruum, so as to imitate every species of urine; it's concentrated solution precipitates the nitrat of lead of a brown yellow, which may be redissolved after some time in much water. On evaporating the liquor from which the precipitate is formed, small shining silverlike crystals are obtained. On treating the precipitate of lead by the blowpipe, it swells, blackens, flies off in a white smoke, and leaves behind it a metallic button of lead.

And nitrats of mercury and silver.

This solution precipitates the nitrats of mercury and of silver, white; mixed with superoxygenated muriat of mercury, which it does not precipitate, it gives to the oxyd separated from it by an alkali a gray flax-colour. It appears to be the ureè which gives to urine the property of forming, with the nitric solution of mercury, a rose-coloured precipitate, already observed and described by Lemery at the end of the last century.

Action of galls upon it.

Gall nuts give the solution of ureè a yellowish fawn colour, without precipitating it.

And of tan.

Tan somewhat changes it's colour, but does not cause



a precipitation, so that it may be of use to separate it in some manner, or rather to separate from it the animal albuminous matter which accompanies it in urine.

Ureë when exposed at first to a gentle distilling heat in a glass retort, and the fire afterward raised so as to red-<sup>Distillation of uree.</sup>den the vessel, is soon melted. Almost on the first access of heat, a white vapour arises, which becomes condensed and crystallized near the mouth of the retort, having every appearance of benzoic acid. Another concrete body soon succeeds this first sublimate, easily known to be the carbonat of ammonia. This new product appears without interruption, even to the end of the operation. There is no oil, nor condensed water, the sublimed salt being only a little brown. The air extricated is at first impregnated with a disagreeable garlick odour, resembling that from putrid fish, and it carries over with it some carbonat of ammonia, which renders the spring water of the tub, in which the pneumat-chemical apparatus is contained, turbid. When the fire begins to be very intense, the odour of the product, always ammoniacal and an elastic fluid, becomes a stench really insupportable, still preserving the same character of putrid fish and garlick. The matter at the bottom of the retort appears in a dry form, of a blackish colour, and covered with a white raised crust; this crust sublimes into a heavy vapour, and attaches itself to the lowest part of the retort above it's bottom. It is the muriat of ammonia. After more than two hours exposure, the coaly residuum left behind afford, by lixiviation, a liquor of the odour of prussic acid, which precipitated, by means of an alkali, solutions of iron, of a blue colour. It still contained some muriat of soda, and a little muriat of ammonia. On calcining the coal, there arose an ammoniacal odour, mixed with that of the prussic acid, or bitter almonds during the whole time. There remained less

than  $\frac{1}{100}$  part of the distilled urée in weight, of a white matter, sharp, soluble, changing violets to a green, effervescing with acids, and having great analogy to carbonat of soda.

Products  
and conse-  
quences of  
this pro-  
cess.

From this process it appears, that urée contains the benzoic acid, muriat of ammonia, and a little muriat of soda; that it is very decomposable by fire; that the most abundant product of this decomposition is ammonia; that neither water nor oil (at least in sufficient quantity to be estimated) is formed; that there is a sufficient portion of carbonic acid produced to saturate the ammonia, and a little prussic acid; that the carbonated hydrogenous gas, the carbonic acid and azot gases, disengaged, are very difficult to determine; that the carbonat of ammonia, impregnated with a little animal oil, horribly fetid, constantly saturated the air of the apparatus, which expanded even to it's extreme part, and that the principles, azot, hydrogen, carbon, and oxygen, so disposed to take a gaseous form, constitute the urée in such proportions, as to be converted by the action of heat into ammonia, prussic and carbonic acids, instead of forming water, oil, and nitric acid, which they form in other circumstances hereafter to be mentioned. Likewise the great quantity of ammonia in the products announces that azot occupies the first place, by it's proportion amongst the constituent parts of urée. This result, very different, as is evident, from what former chemists, and particularly Rouelle jun., Scheele, and Cruickshank had related of this pretended saponaceous, animal extractive, or oily extractive substance, engaged Fourcroy and Vauquelin to obtain the proportions of the products during the distillation, in as exact a manner as possible; and they found, that 288 parts of urée afforded, with 0,03 of loss, 200 parts of carbonat of ammonia, 10 of carbonated hydrogenous gas, 7 of coaly residuum, 68 of

Nature of  
the pro-  
ducts.

muriat of ammonia, of benzoic acid, and of muriat of soda, with some traces of oil, and prussic acid, that could not be estimated; hence it appears, that this process was of great use in determining the composition of this matter.

Two parts of crystalline urée with one of distilled water, being mixed at a temperature of  $10^{\circ}$ , melted, forming thick and brown striae; eight parts more of water being added, the solution, which was very clear and coloured, was poured into a large glass retort by means of a funnel, when a very evident white vapour arose from it, originating from the disengagement of a little ammonia uniting to the water, and the carbonic acid of the atmosphere. This being distilled on a sand bath, to a slight ebullition, and until the solution had acquired the consistence of sirup, it was of a deeper colour, and less crystallized than at first, and the water which came over was a very pure and transparent solution of saturated carbonat of ammonia.

Uree distilled with water.

The same quantity of distilled water being put upon the cooled matter, it was distilled a second and a third time, with the same effect, except that the colour of the solution of carbonat of ammonia was rather brown from the second distillation, and deeper coloured or rather oily, with a deposit of a certain quantity of carbon from the third.

During these three successive operations, in which more than half the weight of urée was afforded of carbonat of ammonia (0,546), this matter was not exhausted, from the formation of it; for dissolved in a fourth quantity of water, it presented the characters of acetous acid, and although it had deposited a little carbonaceous powder, it lost this acid state on four or five days exposure to about  $20^{\circ}$  of Reaumur, and again exhaled ammoniacal water by evaporation; besides it deposited octoedral crys-

tals of muriat of soda, and gave, after being thickened, a shining pearl-like precipitate by the nitric acid, a proof that in spite of the great quantity of ammonia formed, still a portion of ureë remained undecomposed.

It's easy de-  
composition.

Hence it may be concluded, that the water dispersing the molecules of dissolved ureë, and not permitting them to undergo a temperature higher than that of it's ebullition, is sufficient to decompose it; that this temperature which does not disorganize animal substances either completely or easily, but only is capable of changing their consistence, flavour, and odour, has the power of destroying the intimate attraction which keeps the principles of ureë united in a composition at least quaternary; that this phenomenon, hitherto unknown amongst organic substances, announces, that this is of an order of composition still more complicated, if possible, and it's equilibrium more slight and easy to destroy.

Remarks  
upon it.

It is not only in the formation of ammonia that the sudden decomposition of ureë appears, at a temperature and by a process, which before would have been looked upon as impossible; perhaps the formation of carbonic acid in the midst of an aqueous liquid, and at the heat of ebullition, is still more remarkable. It is to be observed, that there is only a quantity of it formed sufficient to saturate the ammonia, for there is neither effervescence nor a disengagement of gas in this experiment, and the proportion of carbon separated during this decomposition of ureë, exceeds the quantity of oxygen which might produce combustion, since a portion of this principle is deposited alone. With respect to the formation of acetous acid, at a heat nearly that of the *baln. mar.* and in so diluted a solution, it appears, that in this the decomposition of ureë, by the long action of boiling water, approaches that which happens during it's fermentation, and which is the case with urine during it's spontaneous decomposi-



tion, and in effect, urine only differs from this artificial solution of ureë, in having this matter combined in part with saline substances that retard the decomposition, when not excited by some fermentative or putrescent principle, which is the case when urine contains a gelatinous or albuminous matter, in a somewhat larger proportion than common.

One part of ureë dissolved in 64 parts of water, was left in an ill-corked bottle, filled to  $\frac{5}{8}$  of it's volume, for about seven weeks, the temperature being above  $165^{\circ}$ , when a fermentation took place in this fluid which was of a brownish-red colour. Bubbles of air continually arose, it became covered with a light foam; the void part of the bottle contained a fluid that extinguished a candle; it exhaled a lively, sharp odour, that was acidulous, urinary, and disagreeable. Some compared it to that arising from marshes, others perceived the odour of vinegar. In distinguishing this last, Fourcroy likewise observed something of ambergris, the odour of which, he had observed before, in a brown, fusible, impure salt, kept for several years in his laboratory. This liquor was left four weeks longer, and as in three months every sign of fermentation had disappeared, it was submitted to distillation, after the addition of twice it's primitive weight of concentrated sulphuric acid. The odorous and evidently acetous product obtained, likewise contained the benzoic acid; both acids were procured by combining them with potash. The residuum contained sulphat of ammonia and carbon.

It's spontaneous decomposition.

During this spontaneous decomposition of ureë, some deep-coloured urine was exposed to the same, and it was observed, that this last underwent it more rapidly; and as some species of pale, or slightly coloured urines, in which, however, tan caused a very evident precipitation, were more rapidly decomposed, and, as it was supposed,

Compared with urine.



that this sudden change might depend on an animal matter that served as a ferment,  $\frac{1}{8}$  in weight of albumen was added to a solution of ureë composed of 60 times it's weight of water. This mixture was found to ferment much sooner than the pure solution of ureë, or the urine. The signs of fermentation were much more evident, the liquor became turbid and full of flocks; a more abundant scum arose to the top, which was more thick and tenacious; the odour was more fetid; more air bubbles were disengaged, and although the acetous acid was produced as in the other two, the quantity of ammonia formed at the same time was more considerable, so that the liquor was alkaline, and the decomposition in general much more advanced.

Is both acid  
and putrid.

This spontaneous decomposition of ureë by a real fermentation, is both acid and putrid at the same time. It differs singularly from that by the fire, by producing more acetous acid and less carbonic acid and ammonia than by heat, which arises from the different attractions. During the spontaneous decomposition, it appears, that the principles are not so ready to form binary unions, their attraction being more tranquil; hence the acetous composition which prevails over the other effects that accompany the production of this acid. The portion of carbonic acid is disengaged as it forms, and cannot remain dissolved in the same liquor as the acetous.

Action of  
acids on  
uree.

The treatment of ureë by acids, which act upon it in a manner very different from what they do on other animal substances, and the comparisons to that by heat, are the means which these chemists employed to obtain a knowledge of it's constituent principles.

The sulphu-  
ric acid.

An aqueous solution of pure ureë mixed with  $\frac{1}{4}$  of it's weight of diluted sulphuric acid, produced no effervescence. On a slight ebullition in a retort, it became covered with an oily and black matter, which fixed on

cooling. The action of fire on this matter produced no oil, as before observed, but a disengagement of carbonated hydrogenous gas, and a precipitate of carbon. The product in the receiver, after the *oleaginous* action of the sulphuric acid, was a yellowish coloured liquor, in which dark brown particles, evidently carbonaceous, were observed to swim; it's odour resembled that of the empyreumatic acetous acid, arising from the decomposition of an alkaline acetite by fire; it's flavour was sharp and hot, like that of distilled oil. It reddened the tincture of turnsole, without precipitating the soluble salts of barytes; hence it contained no sulphuric acid. Saturated with lime, it gave two salts, viz. acetite and benzoat of lime. Hence the benzoic acid accompanies urée in it's crystalline precipitation.

During the first action of the sulphuric acid on urée, a part of this matter had undergone another species of decomposition, for the red residual liquor of this distillation gave sulphat of ammonia in sufficient quantity. This salt, however, formed in part by the union of the sulphuric acid to the ammonia, united to muriatic acid, since the ammoniacal muriat evidently exists in urée, as is proved by the disengagement of muriatic acid effected by concentrated sulphuric acid, and that of ammonia by potash. Yet a portion of urée itself is converted into ammonia during the double action of heat and sulphuric acid.

On repeating these distillations, the same effects take place, but after the first, there remains much urée undecomposed, and which is precipitated again in crystals, on the addition of nitric acid a little concentrated. Hence the sulphuric acid, when weak and warm, converts, by degrees, urée into acetous acid and ammonia, separates the benzoic acid it contains, and takes the ammonia from the muriatic acid, which it conceals in union; at the

It's action  
similar to  
putrefac-  
tion.

The nitric  
acid.

same time it converts a portion into the state of oil, and separates a part of the carbon, which colours, and even renders the solution turbid, from which it may be concluded, that the sulphuric acid acts upon ureë in the same manner nearly as the slow or putrefactive decomposition.

The manner in which the nitric acid acts upon ureë is the most singular of all. It's power on organic substances is well known, and the phenomenon it produces with ureë has been already indicated by Cruickshank in the remarkable precipitation it produces, which is one of the characters that particularly distinguishes ureë from all other substances.

This precipitaté, which is lamellated, radiated, white, shining like satin, soon becoming of flax gray, brown, and even black, in sufficient quantity to fill the vessel, and convert all the urinary liquid into a solid and crystalline mass, in a few seconds, and even at the moment almost as the nitric acid, somewhat strong, is poured on urine, evaporated to the consistence of sirup, or on a solution of ureë sufficiently concentrated, to be of that consistence, is a phenomenon unknown to chemistry in treating animal substances with the nitric acid. To determine the nature of the precipitate, it was cautiously heated, it became soft, and melted like oil; a brisk effervescence took place, and part was converted into nitrat of ammonia. Hence this crystalline deposit is a composition of ureë and nitric acid; it is not pure ureë separated from it's solution by the acid, but the product of an intimate union, which does not take place between any other acid and ureë, and hence ought to be looked upon as peculiar to the nitric acid.

Concen-  
trated.

In order to determine the action of very concentrated, and very diluted nitric acid upon ureë, assisted by heat, as was the case with the sulphuric acid, the most concentrated nitric acid, particularly that more or less impreg-

nated with nitrous gas, being poured on solid urée, excited a considerable effervescence and much heat; the matter rose up, swelled into a foam, melted into a deep red liquor, part rejected or thrown out of the vessel by the numerous bubbles of nitrous azot and carbonic acid gases, which are disengaged with impetuosity. It appeared as if the mixture, agitated and boiling, was going to inflame, and yet this violent action constantly ceased, the mass sunk, and there only remained a portion of white yellowish concrete matter, with a few drops of a red liquor. If this residuum be exposed to a lively heat, it detonates, and inflames in the same way as ammoniacal nitrat. In this process, therefore, the urée is decomposed and converted into carbonic acid and ammonia; but there is nothing of an oily nature; the decomposition, however, being too rapid to determine the products, it was better observed during the slow action of the diluted nitric acid.

Upon urée crystallized by evaporation of the alcohol, Diluted. and deliquesced so as no longer to be of a thick sirupy consistence, was poured an equal part of nitric acid, reddened by nitrous gas, and at 1460 of concentration, united with it's weight of distilled water, in a tubulated retort; but the effervescence being still too great, another equal portion of water was added. After this, the homogeneous, brown, and liquid mixture, only produced a slight and gradual effervescence, but constant and without interruption. The retort was placed on a sand bath which was gently heated, and kept at the same degree during the process, which lasted nearly two days. The most remarkable phenomenon is the disengagement of gas, which is constant and regular, the quantity of which amounted nearly to 24 cubic decimeters; more than  $\frac{5}{8}$  or 25 grains belonged to the urée, as will appear, which make nearly  $\frac{1}{3}$  of the matter employed.

During the first day, more than 18 cubic decimeters of gas came over; and even to the quantity of 10 or 12 cubic decimeters it was composed of azot and carbonic acid-gases, which last was known by means of a lye of pure potash. As to the six cubic decimeters of this first part of the distillation, the azot gas was replaced by atmospheric air.

The second day, nearly six cubic decimeters of gas were obtained, mixed with the oxyd or nitrous gas, and carbonic acid; the liquor was never carried to ebullition, and the uniform effervescence was constantly maintained by very small bubbles, equally disengaged from the whole surface of the liquor.

Towards the time when the production of azot gas ceased, the colour of the liquor, until then red, becoming weaker, passed to a yellow colour, and there was no precipitation, no black flock, nothing of a carbonaceous nature to be seen,

At the same period, the portion of gas insoluble in the lye had a strong odour, and produced tears from its irritation. It communicated this odour to water, and resembled the sebacic, or rather what Berthollet calls the oxygenated prussic acid. This gas, which appeared by the eudiometer to be a mixture analogous to atmospheric air, holding a little prussic acid in solution, only arose after the cessation of the azot gas, and at the moment the nitrous gas became evident.

At the end of the second day, the matter becoming thick, and affording, with difficulty, a vapour to be condensed in the receiver, inflamed with a violent explosion, and a fat carbonaceous matter remained, which gave the water, with which it was lixiviated, a very sensible odour of prussic acid, and of ammonia, with the property of precipitating red solutions of iron in the form of Prussian



blue. After this action of the water, the coal formed nearly the 240th, or 0.0044, of the weight of the urée.

In the receiver there was a greenish yellow liquor, very acid, upon which some oily particles were seen, whilst the penetrating odour announced it's nature to be that of the gas.

In spite of every care, these chemists experienced a pretty considerable loss during this experiment of the decomposition of urée by fire and the nitric acid, which appeared from the strong odour it diffused in the laboratory; but at the same time, the action of the nitric acid on this substance alone shows it to be different from every other animal substance, it's mode of decomposition being limited to the abundant extrication of azot and carbonic acid, and to the formation of ammonia and prussic acid. As to the atmospheric air obtained toward the end, it arises from the decomposition of the nitrous gas, and a portion of oxygen gas set at liberty. Every thing, therefore, during the action of this acid, announces the urée to be a substance surcharged with azot, besides containing hydrogen and carbon singularly disposed to be converted into ammonia, as well as the easy separation of a great quantity of azot become free and capable of taking the elastic state. It's constituent principles are likewise easily detached in a gaseous form, and it appears to have a decided tendency to be sooner and more perfectly decomposed by strong reagents than other substances.

The action of the nitric acid, therefore, as well as that of caloric, proves urée to be a substance containing a great quantity of azot, and the composition of which particularly conceals the union of this superabundant principle with hydrogen, carbon, and even oxygen. As to the small quantity of benzoic acid, and muriat of am-

monia, which appears constantly to accompany urée, they are lost during the process.

The oxygenated muriatic acid.

The muriatic acid has no sensible effect on urée; but in an oxygenated state, partially decomposes it in a singular manner. Some urée of the consistence of sirup, being diluted with four parts of distilled water, and put into one of Woulfe's bottles, to which a second was adapted full of water, and terminated by a tube plunged under a glass vessel, some oxygenated muriatic acid gas was made to pass through it at the moment of it's production. The liquor was of a deep brown, but transparent. The gas passing in great abundance in blebs, was speedily dissolved; small brown flocks, clearer than the liquor, were separated, which soon became yellow, and adhered to the sides of the glass like a concrete oil. The liquor, which always stopped and dissolved the gas, soon became of a white beer colour, the flocks yellow, and those that were precipitated were found after the process to keep up an effervescence for five days, although the gas had only been communicated a few hours until the saturated liquor refused to dissolve it. Six cubic inches of gas were, however, only collected, a third of which was carbonic acid, and the two others azót gas; the oxygenated muriatic acid disengages much less gas from urée than the nitric acid, and fixes rather than volatilizes it's principles; for it appears, that although there was an excess of this reagent in the solution, a great part remained untouched; and as the liquor at the same time contained a sufficient quantity of free muriatic acid, it was found that one portion of the oxygenated muriatic acid gas was first dissolved in the liquor, and precipitated a part of the urée; that soon afterward a second portion of the same gas reacted upon the flocks of precipitated urée, discoloured them, disengaged the azot, consumed

a part of the carbon; in short, decomposed them, and at the same time passed to the state of ordinary muriatic acid, which fixed and retained in the liquor the greatest part of the ureë; by defending it from the action of a fresh quantity of oxygenated muriatic acid. Here the influence of this reagent ended, stopped on the one side by the conversion of about one sixth part of the ureë separated from the water into carbonic acid and azot gases, and into a fat matter composing only two or three hundredths of this one sixth decomposed; and on the other side, by the saturation of five sixths of this matter by the ordinary muriatic acid.

Ureë is very soluble in alkaline lixivia, and appears to have a strong attraction for saline bases. Triturated in a thick and soft state with a lye of caustic potash, a strong odour of ammonia is immediately perceived.

Uree treated by alkalis and salts.

The same takes place with the carbonats of potash or soda; and as lime, barites, and in some measure magnesia produces the same effect; it follows that this animal substance contains muriat of ammonia, which these bases decompose. Another effect is, however, produced when solid or soft ureë is rubbed with dry caustic potash in powder. It's mixture becomes very warm, there arises so large a quantity of ammonia as to make it's formation evident; whilst by the carbonats, it is only from the muriat contained in it. The mixture likewise, become of a very brown colour, lets a substance escape from it's surface, which is equally coloured, and has the appearance of an empyreumatic oil. From this it appears, that potash quickly decomposes ureë, but it was necessary to procure a further decomposition by heat.

One part of ureë in a sirupy form, with two parts of pure solid potash, dissolved in four times the quantity of distilled water, were poured into a tubulated retort, to which a receiver was applied filled one fourth full of wa-

By potash with heat.

ter. It was then heated, and during the process it was found that the ureë was decomposed in a similar manner to that effected by the sulphuric acid, or the spontaneous decomposition of ureë when its solution is placed in a mild temperature. The ureë is changed into ammonia, and the acetous and carbonic acids; the benzoic acid is not changed during this decomposition, but is found amongst the distilled products. Hence the extreme tendency of the ureë to be converted into ammonia, and carbonic and acetous acids, renders the power of the alkali of producing ammonia from animal substances more energetic and rapid, which these chemists have called *ammoniazation*, and which arises from the abundance of azot contained in ureë, and the small quantity of hydrogen; two circumstances which particularly characterize it, for in all the processes to which it is exposed, it is found to contain much more azot and less hydrogen than any other animal matter.

United with  
salts

According to these chemists, the muriat of soda obtained from urine is in the form of octoedral crystals, whilst that of ammonia is separated in the form of cubes. Many errors arising from chemists having been deceived by their form, in taking the muriat of ammonia for that of soda, and the latter for the former, Fourcroy and Vauquelin found, after a great number of curious experiments, that the variation of their form, or the conversion of the primitive cube of the muriat of soda into an octoedron, and that of the primitive octoedron of the muriat of ammonia into a cube, is owing to the combination of these salts with the ureë. This property, the first of the kind hitherto observed, and which they consider as one of the most extraordinary in the analysis, supplied them with a character of this animal matter; and it is a fact now well ascertained, that ureë dissolved in the same water with the two muriats changes their natural form by

combining with each, and penetrating the laminæ of their crystals.

Although the chemical examination of urée is at present very incomplete, and only comprehends it's analysis, without the least attempt at the synthesis, it remains to collect in a rapid point of view the properties it presented, and the means they afforded of determining it's nature, the proportion of it's principles, and a comparison with other animal substances. Recapitulation.

A. A shining crystallized mass composed of yellowish-lamellæ or tablets contracted in the centre, or of grains united and condensed; it's deliquescent parts always brown; an immediate separation from strongly evaporated urine, on cooling, or from alcohol, containing it and similarly evaporated and cooled; a garlic urinous odour, of an insupportable fetidity, weakening those who are for some time exposed to it; a strong, penetrating, and sharp flavour; adhering to the vessels which contain it, and so hard as to be cut with difficulty; such are the physical properties which characterize and distinguish it from other animal substances.

B. Quick fusion, rapid intumescence by fire, volatilization, and disagreeable odour on being strongly heated, easy destructibility by distillation on the open fire, enormous production of carbonat of ammonia, exceeding two thirds of it's weight, constant vestiges of prussic acid, very little carbon, muriat of ammonia forming more than one sixth of it's mass, and some hundredths only of benzoic acid; such is the manner of it's decomposition by heat, which places urée in an order of substances, of which no other analysis by fire has given an example.

C. So strong an attraction for water, which it immediately takes from the atmosphere, as to become soft and melt on it's surface; a clammy and sirupy state, with a deep brown colour, owing to this deliquescence, so that



the difference between this honeylike portion, and the crystallized portion beneath, might incline a person to think them not the same; rapid solution in small quantities of water, it's various colour according to the proportion of water, from a reddish brown and almost black, to a lemon or slightly orange, which imitates at the will of the chemist every possible urine, from the palest to the highest coloured; decomposition, conversion into carbonat of ammonia by hot water even before ebullition, provided it's action be long continued; these series of phenomena give urée a very distinct place amongst animalized substances.

D. Very strong fermentation, when it's very diluted solution in water is mixed with an animal gelatinous or albuminous substance; scarcely any when alone, and without any animal matter that can serve as a ferment; formation of carbonat and acetate of ammonia, products of this species of putrid fermentation, source of the rapid putrefaction of urine, of the noisome odour it diffuses, and of the various species of changes the different matters it contains undergoes; these, as well as the preceding characters, likewise serve to determine the nature and properties of urée.

E. Slow conversion into acetic acid and ammonia, by the sulphuric acid aided by heat; sudden precipitation by strong nitrous acid from it's concentrated solution into shining lamellated and silkylike crystals; slow decomposition; almost perfect fusion into carbonic acid and azot gas, extremely abundant, and which are disengaged for a long time by the action of the weak nitric acid, assisted by a gentle heat; decomposition into ammonia and carbonic acid by oxygenated muriatic acid, and solution and preservation by the common muriatic acid, which show it to be a very different composition from other animal matters.

F. Lastly, rapid solution by potash, and conversion into carbonat and acetite of ammonia, by the united action of a weak heat; and of fixed alkali; intimate union with the muriat of soda, the cubical form of which it changes to the octoedral, and *vice versa*, with the muriat of ammonia; these leave no doubt on the peculiar nature of urée.

The remarkable differences which urée has presented during it's analysis are manifestly owing to the great quantity of azot it contains, but to have a satisfactory knowledge of it's nature, it is necessary to determine the proportion of it's different principles. With this view, it has been found, that the products of it's distillation answered to the results of the other kinds of it's decomposition.

It has been before observed, that 288 parts of urée <sup>Component</sup> afforded by means of heat 200 parts of carbonat of <sup>parts of</sup> ammonia, ten parts of carbonated hydrogenous gas, and seven of a coaly residue, which with three parts of loss, left 68 for the muriats of ammonia and of soda, and benzoic acid, matters which, although they constantly accompany this substance, those chemists regard as foreign to it's nature. Hence it is necessary to reduce 288 parts of urée extracted from urine by evaporation, and it's treatment by alcohol, to 217 of real urinary matter, 200 of which are converted into carbonat of ammonia, ten disengaged in the form of carbonated hydrogenous gas, and ten of fixed coaly residue. Now 200 parts of carbonat of ammonia, sublimed and crystallized, being formed of 90 of carbonic acid, 86 of ammonia, and 24 of water, and each of these three urinary compositions being reduced to it's constituent principles, it follows, on adding to the carbon of the carbonic acid the coaly residue, with the addition of the three

quantities of hydrogen contained in the ammonia, in the water, and disengaged in gas, as well as that of the oxygen forming part of the water and carbonic acid, that the 217 parts of urée really contain 85,2 of oxygen, 69,4 of azot, 32,2 of carbon, and 30,2 of hydrogen; which make very nearly for the 100 parts of this animal matter 39,5 of oxygen, 32,5 of azot, 14,7 of carbon, and 13,3 of hydrogen. It is, however, to be observed, that of the  $39\frac{1}{2}$  of oxygen there are about 11,0, which belong to the water perfectly formed, as well as two of hydrogen, so that the azot is the predominant principle of urée, both as to the phenomena it presents, and in the proportion of its constituent principles; hence the long effervescence it makes with the nitric acid, and the quantity of ammonia it affords in every species of its decomposition; and although the hydrogen is in small quantity, it is more than sufficient to the formation of ammonia, and the excess is disengaged in a free state, carrying with it a little carbon, rather than enter into an oily combination, because the carbon finds a sufficient quantity of oxygen for combustion; thus there can be no oil, and in reality only a few slight traces of it are to be seen in the distillation of urée. These circumstances prove it to be a composition ready to pass into the state of carbonat of ammonia whenever the equilibrium of its parts is the least broken, and to be destroyed by the smallest efforts.

It's utility  
considered  
in a patho-  
logical view.

A knowledge of the properties and nature of urée naturally leads to endeavour to find out the influence it may have in the animal œconomy, and in the theory and practice of the chemical arts, in which urine is employed.

The greater part of physiologists have looked upon urine as a saline lixivium, as the natural evacuation of the salts introduced into the system with the aliments, or formed by the actions of life. Boerhaave, however, regarded urine as an excretion of much more importance than

merely carrying away simple saline matters; he announced it to be a means of expelling the portion of our humours tending to putrefaction, and disposed to bring the others into the same septic decomposition; but this beautiful idea of the Leyden professor was not attended to.

The discovery of urée by Fourcroy and Vauquelin, confirming in some respects the first idea of Boerhaave, correcting at the same time the false notion of an animal oil which he had conceived, affords a more exact explanation of the urinary evacuation. It appears to be an excrement of a peculiar nature, and very different from any of the others. The great quantity of azot it contains evidently confirms it to be an evacuation of this principle, and in this respect, the kidneys may be looked upon by the physiologists as the excretory organs of the azot, in the same manner as the lungs are of the carbon and the liver of the hydrogen. Until this discovery, the way was unknown by which this principle was evacuated, which from it's presence distinguishes and characterizes the animal parts, and consequently is so apt to be superabundant in the body. The mystery is now unravelled. This azotic matter is separated from the blood carried by the renal arteries, by which means the vital fluid, on losing the superabundance of this principle preserves the equilibrium of it's composition so necessary to it. One of the most remarkable properties of urée being the formation of ammonia, and this being one of the most characteristic products of putrefaction, it is natural that Boerhaave, who observed this abundant ammoniacal production in urine, should have looked upon this liquor as charged with a matter extremely putrescent, and as conveying out of the body the cause, which if suffered to remain too long a time would be productive of a septic decomposition. Although there is no positive experiment on the subject, it is very probable ac-



cording to these chemists, that when the urée is not separated from the blood, the excess of it's elements, and especially of the azot in our humours, is very capable of giving rise to diseases, and particularly those of a putrid kind, since the present knowledge of chemistry attests that organic bodies are more susceptible of putrefaction according to the quantity of azot they contain, from the multiplied attractions it's presence produces in their component parts.

This function of the kidneys to deazotize in some measure the humours, and perhaps even the solids of the body, demands the attention of physicians; for the urine may be looked upon in future, not only as an evacuation of the superabundant phosphats, but of a matter very much disposed to the putrid ammoniazation; and it may be of consequence to be able to determine the proportion and the state of the urée in this excrementitial liquid; to estimate it's different quantities, and it's nature in different diseases; to determine more particularly the specific gravity of the urine, where the urée, five or six times greater in quantity than all the other salts which this fluid holds in solution, has the greatest influence; to seek in the degree of colour the proportion of this substance; to analyze it where this matter appears to be entirely wanting, as in hysteric or hypochondriac diseases, and convulsive and nervous affections, and where it is more abundant than usual, as at the end of some fevers, in diseases of the liver; and lastly, to examine it's relations with the uric acid, a great abundance of which Scheele had observed in urine at the time of a crisis. Researches like these may be very important in the solution of many phenomena relating to pathology, which at present are not to be explained, although these two chemists have made the attempt. It is their opinion, that when urine remains too long in the bladder, as in retention, it con-



tracts an ammoniacal acridness, which is manifest from it's strong fetid odour, and brown colour on being evacuated by art; that it is to this formation of ammonia the insupportable pain is to be attributed which these patients often experience; and this is proved by the injection of water slightly impregnated with ammonia into the urinary canal, an experiment which Dr. Swediaur found to be a good imitation of the blennorrhagia from the irritation and mucous secretion it excited.

In old people, where the sensibility and irritability of the fibres of the bladder are weakened, and who often die in consequence, the urine which remains too long a time becomes in the same manner ammoniacal and fetid; it flows in a turbid, viscous and ropy state, from the gelatinous mucilage which the addition of ammonia separated from the acid that holds it in solution in the natural state. The same phenomena sometimes take place in the pains and urinary stoppage occasioned by the presence of a calculus in the bladder. The urine after calculous tortures is often rendered thick, and in some points glairy as glue, the chemical effect of the ammonia formed, and of the septic change the ureë has already undergone in the bladder. The same happened with three calculous patients, to which these two chemists had administered by injection a very diluted solution of potash; the urine flowed glairy, and so loaded with flocks as sometimes to stop the catheter. Four patients with the gravel, for which they took for several days a few drops of lyc of potash in some linseed water, had their urine rendered equally thick and ropy from the action of the alkali upon this liquid.

With respect to the application of the discovery of urine to the arts, it may be divided into four principal parts. 1. The artificial formation of nitre. 2. The employment of urine in the process of scouring woollens.

It's application to the arts.

3. The extraction of ammonia. 4. The extraction of muriat of ammonia from it.

1. In making nitre.

1. Manufacturers of saltpetre have long ago observed, that soft stone, arable ground, earth impregnated with urine, soon became loaded with this salt: hence they preferred materials of this nature to all others. Thus in Switzerland and Sweden the urine of cattle is made use of in the formation of saltpetre, and in several artificial nitre manufactories in France, the earthy mixtures, and the relics of vegetables and animals for that purpose, are moistened with urine; from which it is evident, that this liquid contributes to the formation of the nitric acid, from the considerable quantity of azot that enters into the composition of ureë, one of it's properties not to be exceeded by any other natural substance. The contact of the atmospheric oxygen, and of several vegetable matters, appears to prevent, in the making of saltpetre, the formation of ammonia in ureë, and to determine that of the nitric acid.

2. Scouring cloths.

2. The ancients made much more use of urine in cleansing woollen stuffs, particularly white ones, than the moderns; and it appears that for this purpose it was necessary to keep it a longer or shorter time before it was ready. It was anciently collected in Rome, as mentioned by Pliny, Martial, Macrobius, &c. for the use of scourers, who were obliged to reside either in the suburbs or in some of the frequented streets, from the nuisance the putrid urine occasioned. According to Suetonius, the emperor Vespasian put a tax upon it, as his historians tell us, *urinae vestigial commentus est*: it continued two centuries, till the time of Anastasius; and we read also of *vestigial pro urina jumentorum et canum*, which was exacted from every person who kept cattle. It is collected for the cloth manufacturers at Leeds, Halifax, &c. under the name of *old lant*.

Every thing proves that the putrid urine thus used acted by the ammonia that was formed, and that it was preferable to fixed alkalis, as they were known to change the texture of the wool, whilst ammonia does not sensibly affect either it's strength or it's nature.

3. The art of extracting the *ancient volatile salt*, or the carbonat of ammonia sublimed from urine, has been long known. It was practised towards the end of the seventeenth century; and the theory is well explained from a knowledge of the nature of urine. It is well known to afford it in large quantity after putrefaction; but it is necessary to remark, on it's ammoniacal conversion, that when urine has been strongly evaporated, and to dryness, it no longer gives so much carbonat of ammonia by fermentation, even if the same quantity of water be added as existed before. This arises from the separation and destruction of a gelatinous or albuminous animal matter during the evaporation, which before served it as a ferment, and enforced the formation of the ammonia; whilst abandoned alone, and without a ferment to it's spontaneous decomposition, the ureè which undergoes it difficultly and slowly, in part passes to the state of acetic acid, which diminishes in proportion to the quantity of ammonia. Hence the great advantage of letting the urine become putrid, instead of evaporating it when fresh in order to obtain the carbonat of ammonia.

4. Lastly, the extraction of muriat of ammonia, although some chemists, and especially Rouelle, junior, nearly denied the existence of it in human urine, having been concealed by the cubic form which the ureè gave it. This is easily separated from the residuum after the urine is advanced in putrefaction, by means of heat, being found almost in an isolated state; besides, the use of carbonat of ammonia, so abundantly furnished by this fermented liquor, in decomposing earthy muriats,

Making of ammonia.

4. Extraction of muriat of ammonia.

may be considered as singularly increasing this production of ammoniacal muriat, and in this respect the natural decomposition of ureë or urine is one of the most rich and useful materials in the manufactures of salts.

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#### URINE OF THE HORSE, &c.

Urine of the  
horse.

It is a very peculiar fact, and first announced by Rouelle, that the urine of animals which feed on vegetables contain no phosphoric acid, but a much greater quantity of extractive matter than the human. Giobert, on the contrary, affirms that the urine of horses is nearly as proper for the making of phosphorus as the human; but he has not supported his assertion by any positive experiment, and Fourcroy has proved that the acid which supplies the place of the phosphoric is the benzoic.

Examined  
by Rouelle.

According to Rouelle, the urine of the horse has a peculiar smell, approaching very much to that from the cow. It is in general turbid, either when first voided, or a little after; exposed to the air, it soon becomes covered with an earthy pellicle, which, when broken, falls to the bottom, and is succeeded by another that continues several days; twelve pints of urine often afford six or seven ounces of this pellicle. This urine is very pituitous, which quality it loses on being boiled.

It always changes the blue of violets to a green, and both the mineral and acetous acids effervesce with it. The soapy extract is in large quantity, the extractive matter is much greater in quantity than in the human, and that of the cow, and is black. This chemist extracted neither muriat of ammonia, nor phosphoric salt from it, but like those of the cow and camel, he obtained the digestive salt of Sylvius, vitriolated tartar, and calcareous earth, which he converted into lime.



The urine of the horse has been examined by Fourcroy and Vauquelin; they found that it contained a great quantity of benzoat of soda, combined with an oily matter approaching to a resin; that the nitric acid precipitated some white silky crystals from its alcoholic solution, the nature of which is unknown; and that this urine is composed of

By Fourcroy  
and Vau-  
quelin.

0.011 of carbonat of lime, held in solution by the carbonic acid.

0.009 of soda.

0.024 of benzoat of soda.

0.009 of muriat of potash.

0.007 of a peculiar animal or vegetable matter.

0.940 of water, mucilage, but no lithic acid.

The urine of the cow, when fresh, has, according to Rouelle, a very strong peculiar smell, it has in general little colour, but becomes deeper on being kept; it has then nearly the beautiful amber colour of the human. It is often turbid as well as that of the camel, from the quantity of matter it contains beyond the point of saturation. It changes the sirup of violets green, and if exposed twenty four hours to the air, very singular crystals are formed on the surface; it effervesces with acids from the free vegetable alkali it contains; the volatile and fixed alkalis have no effect upon it. It contains the saponeaceous and extractive matters like the human, but the first affords more oil and no muriat of ammonia, the remainder is alkaline, and effervesces strongly with acids, which is not the case with the human; with respect to the second, it is more abundant, and on analysis, affords the same as the first, viz. volatile and fixed alkalis.

Urine of the  
cow and  
camel, by  
Rouelle.

The same chemist obtained from the urines of the cow and camel, which resemble each other in many points, a free vegetable alkali, vitriolated tartar, digestive salt of



Sylvius, but no phosphoric salt, at least he could obtain none by the ordinary methods.

He also got from the urine of the cow, not constantly, but at three different times, a volatile acid salt in small needles, or very light silvery shining leaflets, which sublimed like the flowers of benzoin, and resembled them in taste. It is little soluble in water, but very much so in alcohol and ether. It changes the sirup of violets to a beautiful red colour, unites to fixed alkali with effervescence, and is either decomposed or disappears from putridity, since putrid urine never afforded this salt.

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#### SWEAT.

A great analogy has been found to exist between the fluid emitted by cutaneous perspiration and urine, and it has been observed, these excretions mutually answer the same purpose in many cases, and we are therefore naturally led to consider this vaporous fluid as of the same nature as urine. Physicians have found that it's qualities are subject to variation; that it's odour is faint, aromatic; that it is alkaline, sour; that it's consistence is sometimes glutinous, thick, tenacious; that it leaves a residue on the skin, and that it often tinges linen with various shades of yellow. Very few chemical experiments have been made upon this fluid; Berthollet affirms, that it reddens blue paper, and that this effect is produced more particularly from that which is procured on those parts affected with gout. He thinks it contains the phosphoric acid; and Henckel saw a person whose body during perspiration was become phosphorescent.

Pliny's Natural History.—Macquer's *Wörterbuch von Leonhardi*. art. Harn.—Fourcroy's *Elements*. vol.

4. English Transl. art. Urine. 1788.—Haller's *Elementa Phys.* art. Urina.—Rouelle in the *Journal de Méd.* tom. 40. Nov. 1773.—*Encyclop. Méthod. Chimie.* tom. 1. p. 204. art. Acide Ouretique.—Sur le Sel fusible entiere extrait de l'Urine humaine, par M. Fourcroy. *An. de Ch.* tom. 7. p. 183.—Proust in *Rosier's Journal de Phys.* 1781.—Klaproth ueber die Natur des Proustischen sogenannten Perlsaltzes, in *Crell's Chem. An.* 1785.—Berthollet sur l'Acide Phosphorique de l'Urine, in the *Mém. de l'Acad. de Paris.* 1780.—Mémoire sur la Nature de Rachitis. *An. de Ch.* p. 113. tom. 18.—Gaertner. vide *ibid.* No. 71. p. 170.—Halle *Observat.* sur les Phénom. et Variat. qui présente l'Urine considérée dans l'Etat de Santé, *Mém. de l'Acad.* p. 469. 1779.—Brugnatelli ueber den Bodensatz des Harnes in *Crell's Chem. Annalen.* *An.* 1787.—Experiments and Manner of distinguishing several Diseases by the Urine, by Mr. Cruickshank. *Philosoph. Mag.* No. 7. Déc. 1798.—Mémoire pour servir à l'Histoire Naturelle Chimique et Medicale de l'Urine humaine, &c. par les Cits. Fourcroy et Vauquelin. *An. de Chim.* p. 80. No. 94. & p. 113. No. 95.

## FÆCES.

THE fæces not only vary in their consistence in different animals, but even in the same animal at different times, and this variety is found to pass through all the degrees, from a fluid state nearly to a firm solidity. The colour is equally variable: in man it is more or less yellow; in quadrupeds, as the horse and cow, it is a dark green; in the pig it is grayish; in the dog it is sometimes white, at other times black; in some kinds it is white like chalk, as in those particularly that live by suction, viz. the woodcock and snipe; in some insects it is red, as the bug and flea, whilst in others it is green.

Their great  
variety.

The odour also is various. It is generally more or less fetid, but in the cat it is extremely so, and more so in the carnivorous than graminivorous animals; whilst in those of some animals there is scarcely any smell.

Since the fæces are the refuse of the food, by which animals are supported, it is natural, however, to suppose that these differences must arise from the nature and properties of the food the animal takes in; and this difference of food will equally have an influence on them when submitted to chemical analysis. With respect to their colour, it generally arises from a portion of bile they contain; and as to their fetid odour, Fourcroy is of opinion it arises from the commencement of a putrefaction, which already takes place during their passage through the intestines, although some chemists will not allow of any such putrefaction.

Some of the old alchemists had an idea that the philosopher's stone was concealed in animal fæces, and on this account, many experiments have been made, parti-

cularly upon the human, and those of quadrupeds ; but from the great obscurity that is thrown over their writings, nothing satisfactory is to be learned from them. The only chemist, according to Macquer, who has investigated the nature of human fæces, is Homberg, and this unpleasant operation he undertook for the satisfaction of a friend, who affirmed, that a white oil, of no unpleasant odour, was to be extracted from them, which possessed the valuable property of fixing quicksilver in such a manner as to be converted into silver. Homberg found the oil, but it had no such effect on quicksilver.

Human.

Fresh human fæces, distilled on a water bath, even to dryness, afforded nothing but an aqueous, clear, tasteless fluid, of a disagreeable smell ; no volatile alkali, however, appeared, although it had approached to a putrid state, whilst putrid substances always afford it at the same heat.

The dry residue, on increasing the heat by degrees, gave a volatile alkaline spirit and salt, a stinking oil and a carbonaceous portion remained, consequently the same substances as other animal matters.

The same sort of fæces lixiviated with water, filtered and evaporated, afforded an oily nitrated salt, which fused on red hot coals like saltpetre, and heated to a certain point in close vessels, inflamed. Putrid excrements gave an oil without colour or smell. To this it may be added, that the fæcal matter which Homberg analyzed, was from a person who had been fed on coarse bread, and Champagne wine.

We learn from Haller, that the human fæces contain a small quantity of acid, which is found in greater abundance in the ruminating class ; and Brugnatelli speaks of an acid existing in the fæces of carnivorous birds ; those of the dog, however, contain none of it. Those of ruminating animals likewise effervesce with the nitrous

acid, which is produced in a much stronger degree with the fæces of the dog, hen, and pigeon. In some countries it is not uncommon to make use of pig's dung instead of soap.

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#### MECONIUM.

THIS is the matter contained in the intestines of the fœtus, that has not respired, and which is rendered by infants a few hours after their birth. It is particularly found in the large intestines, in the duodenum, and even in the stomach; it is sometimes in considerable quantity. It is consequently the first excrement that is formed, and it's origin has been almost always attributed to the bile.

It is of a brown, greenish brown, or black colour, of the consistence of liquid honey, or pretty thick sirup, is viscous and ropy. It is generally without any odour or flavour, but sometimes it is slightly fetid.

Bordeu appears to have been the first who has particularly attended to the meconium; he has inserted into his medicinal analysis of blood the examination of this matter, made by Bayen and Deleurye, and it is from this article that Fourcroy, in his *Système des connaissances chimiques*, has collected his materials for this subject, of which the following is an account.

Examined  
by Bordeu.

According to Bordeu, the meconium is commonly without any odour, but sometimes it has a disagreeable, earthy, mouldy smell; it is black in the large intestines, and greenish in the others; it is more of a mucous than oily nature, appearing to him to be unflammable; there is no predominant mark of acidity or alcalescency; it has, however, a saponaceous character, being both soluble in water, and in alcohol. He looks upon it as a



stercoral matter, as the first attempt of the action of the intestines.

After Borden, Bayen made an analysis of this matter, Bayen. and although his researches did not extend to any great degree of minuteness, they are sufficient to give an idea of its general properties. This liquid, analysed by Bayen, was of a deep olive colour, without odour, and almost without any flavour, and of the consistence of an electuary, or thickened mucilage. It tinged linen yellow, and this colour could not be extracted by water, although it took the same yellow tinge. Diluted with sixteen times its weight of water, it communicated its colour to it very slowly, and more than one half of a gross matter was precipitated, that on exsiccation became brown. Heated in an iron spoon, it swelled, emitted at first an aqueous, then an oily vapour, but always of a less disagreeable smell than that of other animal substances; it did not, however, inflame, although the spoon was red hot. Exsiccated on the water bath, it lost more than four fifths of its weight, and became a brown, opaque mass, easy to pulverize, exhaling a mild agreeable odour, resembling that of evaporated milk; it was somewhat bitter. A little of this dried meconium, digested with ten times its weight of alcohol, gave it a deep yellow colour, and when evaporated, about one tenth of its weight was left of a saffron yellow matter, bitter and transparent, perfectly resembling that which is extracted from bile by the same means. The residuum, undissolved by the alcohol, was black, although it gave to water a yellow colour. The greatest part of the dried meconium, heated in a small glass retort, afforded half its weight of water, about one half of oil, some carbonat of ammonia, and an elastic fluid, which Bayen looked upon to be air. A coal remained, forming one sixth of the mass; which, on being roasted, afforded still more ammonia, became

incinerated on it's surface, and hard at it's centre, although exposed to a red heat five or six minutes, and this is the case with all animal charcoal. When roasted longer, it became friable, although it remained black; it had lost somewhat less than half it's weight, and effervesced with the nitrous acid. From these experiments, Bayen concludes, that the meconium is a real excrement, but milky, and already mixed with bile like that of adults.

Deleurye. Borden has likewise given some observations of Deleurye on this matter, which to a certain point are opposite to those of Bayen, as they announce a fetid odour, whether from this liquid when heated by itself or with water. The same person has observed, that in many infants that died at birth, and from which he collected the meconium, he found the gall bladder containing a liquid more inclined to a reddish colour than that of the bile; in fetuses dead before they had respired, he found no liquid in the stomach, only a gluey, reddish coat, and the same in the small intestines; in the cœcum the coat was white and thick; in the colon it was still thicker, but brown and resembling the meconium, particularly near the rectum. The internal coat of the colon was spotted with the brown shade of the meconium, and very difficult to clean; the rectum was full of viscous meconium, difficult to take away, and it obstinately preserved the colour of this excrementitious liquid.

These facts Borden thinks are sufficient to conclude the meconium to be the purest part of the bile, accumulated in the liver, becoming black in proportion as it loses it's water, tinging all the membranous parts to which it adheres of a yellow colour, emitting particular emanations to the surrounding parts, mixed with mucous, stomatic, and pancreatic humours, and forming a column of matter upon which the intestines are moulded, and from which they take their form.

The enlightened chemist needs not be informed, that the experiments and observations on this matter are at present insufficient, to produce any satisfactory conclusions as to the use of it in a pathological point of view.

It now remains to give some account of the experiments on the dung of other animals.

Vauquelin having observed the great quantity of carbonat of lime, which is daily formed in the oviduct of hens that lay, and the extreme quickness with which this earth is deposited upon the substance of the egg, was induced to make some experiments on this subject; being convinced that this matter was previously separated from the blood by the kidneys, and afterwards carried into this organ by some liquid that serves it for a vehicle.

Vauquelin's experiments on the excrements of poultry.

On calling to mind that the urines of the cow, the horse, the camel, the rabbit, and in general of all *herbivorous animals*, contain carbonat of lime, without any mixture of phosphat of lime, and that this last remains almost wholly in the residuum of digestion; it will not be astonishing, that hens which are nourished with matters of the same nature should only furnish carbonat of lime in their urine, particularly on reflecting that their burnt excrements only contain very little of this calcareous salt, and scarcely any thing but phosphat of lime, although their aliments afford much more carbonat of lime than phosphat. It appears, therefore, that during the act of digestion, some carbonic acid is formed from the alimentary substances, which dissolves the lime, and favours its passage into the circulation, from whence it is afterwards separated by the kidneys, and carried into the oviduct, where, by a peculiar affinity, it attaches itself to the substance of the egg.

Vauquelin found that nine egg shells weighed, according to the new weights, 44,796 grammes, which, divided by 9 = 4,997 for each shell. Thus a hen which has

Weight of shells.

laid 90 eggs in four months and a half, must have formed in that time 447,959 grammis of carbonat of lime, excepting the deduction of the gluten, which unites the calcareous parts.

Quantity of animal gluten.

These 44,796 grammis of egg shells, calcined to blackness, lost 8,321 grammis; the residuum dissolved in the nitric acid with great effervescence, and with an odour of sulphureous hydrogen, there remained 0,217 grammis of coal.

The nitric solution was white; having boiled it a sufficient time to deprive it of the carbonic acid that might have combined with it during the solution, some ammonia was mixed with it, and 0,58 of a gramm of phosphat of lime were obtained; thus there remained 40,178 grammis of carbonat of lime, from which it appears, that 1000 parts of egg shells are formed,

1st, of carbonat of lime	.....	896
2d, of phosphat of lime	.....	57
3d, of animal gluten	.....	47
Total	.....	<u>1000</u>

Medium weight.

The weight of eggs vary according to the sort of hen, according as the laying is more or less accelerated, and various other circumstances; but from a number of experiments Vauquelin fixes the medium term at 58,117 grammis. Hence a hen that has laid 130 eggs in six months, which is pretty common, has formed 7486,226 grammis, or 7 kilogramms, 4 hectogramms, 8 decagramms, 6 grammis, and 226 thousandths of a gramm of matter employed in the formation of these eggs, of which 641,635 grammis are to be subtracted for the shells; there remain then for the substance of the egg itself 7333,793 grammis, or 14lb. 15oz. 7drs. 8grs.

Dung of the hen and cock compared.

When the dung of the hen is attentively compared with that of the cock, the first is observed to be blacker,

and infinitely more meager and exhausted of nourishing matter than that of the cock. Besides this last contains a great quantity of a white cretaceous-like matter, which covers it, although easily detached from it.

Vauquelin had, at first, supposed this white matter to be phosphat of lime, because it dissolved in acids without effervescence; but other circumstances, to be related, soon changed his opinion.

Equal quantities of hen's and cock's dung were calcined in two different crucibles; the first left 5,201 grammes of residuum, and the last only 3. Their ashes dissolved in nitric acid without effervescence; but that of the hen emitted an odour of sulphureous hydrogenous gas.

The residuum of that of the hen, insoluble in nitric acid, was 2,335 grammes, and of the cock, 1,06 gramm, and were nothing but fragments of stone and sand, mixed with a small quantity of coal that had escaped combustion.

The filtered solutions of these two sorts of ashes afforded very abundant deposits by the addition of ammonia, which proves that the matter dissolved by the nitric acid was phosphat of lime. The precipitate furnished by the excrement of the cock weighed 1,166 gramm, and that of the hen two grammes.

Quantity of  
phosphat of  
lime in both  
compared.

Having thus separated the phosphat of lime from the nitric solutions by ammonia, which, after this last, produced no further change in them, the carbonat of potash gave rise to new precipitates, which were carbonat of lime, the weight of which, in that of the cock, was 0,265 of a gramm, and in that of the hen, 0,185 of a gramm.

It follows therefore, first, that in the excrements of these animals, besides the phosphat of lime, there remains carbonat of lime. Secondly, that if these burnt excrements did not effervesce on being dissolved in acids,



it arises from the carbonic acid having separated from the lime during calcination.

*Reflections.* The result of these experiments seems contrary to what reason might indicate, for if a part of the calcareous earth serves to form the envelope of the egg in laying hens, their excrements ought to contain proportionally a less quantity of this substance than those of the cock; but on recollecting that hens, during this epoch, take at least two or three times more food than the cock, that the excrements of the first are much more abundant, more meager and more exhausted, it will be easily conceived how it may happen, that besides the portion of calcareous earth employed in the formation of the egg shell, there still remains more in their excrements than in those of the cock. Hence a hen that has layed 130 eggs in the space of six months, the weight of which amount to 7333,793 grammes, deducting the weight of the shells, has need for the formation of this animal matter of a greater quantity of nourishment, in part useless to the cock, and consequently his excrements ought to be more abundant, more meager, and more charged with calcareous matter.

But it may be said, if the carbonat of lime tends towards the oviduct in the female at the time of laying, it ought to be formed, and afterwards found in the excrements of the male, having no organ to dispose of it, and yet these excrements do not afford a greater quantity than those of the hen.

This objection Vauquelin opposes, by what has been said before, relative to the quantity of nourishment compared to that of the cock, which the hen has need of during her laying, and by what will be laid down hereafter on the comparison of the excrements of the hen when she lays and when she does not.

Although the quantity of carbonat of lime appears sufficient in general for the formation of the shell; it is not, however, inexhaustible, for it has been observed, that when the laying is accelerated, the shell is much lighter, and very often the eggs are only covered simply with a membrane; hence it appears, that the calcareous matter in this last circumstance is not formed in the same proportion as the matter of the egg itself.

There are likewise circumstances where the calcareous matter is more abundant than necessary for the formation of the envelope, for it is not rare to see a hen that has layed in the morning lay another egg in the evening, which is very small, and with a thick shell, and only filled with a white transparent glare, without any yolk. Hence it appears, that when the descent of the egg from the ovary into the oviduct does not take place soon enough, the albumen becomes covered, by a peculiar affinity, with the calcareous matter, and forms a species of sterile egg.

It is very well known, that at the time of laying, hens eat much more than at any other season of the year, that the cock collects for them food, calls and invites them to eat, by a peculiar language; that their excrements are infinitely more abundant and more exhausted than those of the cock. It has likewise been observed, that during laying, hens render none, or scarcely any of that white cretaceous-like matter which covers their excrements at other seasons, whilst the cock renders it always; but that as soon as the hen begins to sit, this matter reappears; and further, as they only render their excrements at very distant intervals, they evacuate a pretty large quantity of a clear liquid, separated from the excrements, which soon after becomes turbid, and deposits a white matter that effervesces with acids; it contains carbonat of lime. The white cretaceous-like matter abovementioned, which

Excrements  
of laying  
hens com-  
pared with  
others, and  
with those  
of the cock.

Matter

which covers the dung of the cock, and hens which do not lay.

It's properties.

envelopes, or simply accompanies the dung of the cock, and of the hens that do not lay, submitted to different experiments, has the following properties,

1st. It is insoluble in cold, and boiling water.

2d. It burns in the fire like animal matter, and leaves scarcely no residuum.

3d. It dissolves in the nitric and muriatic acids, without effervescence, and it's solution affords no precipitate by alkalis, whether caustic or saturated with carbonic acid, it only becomes of a yellow colour.

4th. It's solution in acids forms with tan contained in the infusion of gall a very abundant white precipitate.

These properties prove this substance to be of an animal nature; it is not, however, gelatin, since it would have been soluble in boiling water, although perfectly dry, and since there is only this and albumen susceptible of uniting with tan, and forming a combination insoluble in water, it is evidently a real albumen, or white of egg coagulated and dried by the air. "Hence," says Vauquelin, "although the cock does not lay, there is a substance prepared in his organs, proper to form the white of egg, and henceforth, it will, perhaps, not be ridiculous to believe, that these animals, under some circumstances, may render a species of egg, and the opinion of the country people be no longer a prejudice. It is sufficient, that a certain quantity of glair or *albumen* sojourn a certain time, and the urine on passing cover it with carbonat of lime, with which it is saturated. I confess I never saw this phenomenon; but so many people are said to have seen it, that it is difficult not to believe something of it."

Early refectum of burnt oats examined.

Vauquelin, in order to determine more exactly what took place during digestion in these animals, endeavoured to find out the principles oats are composed of, with which they are nourished, and in what proportions they

exist. This view in particular was to determine what relations the earthy parts bore to each other, such as the lime and the phosphat of lime. He found that oats contain about 0,031 their weight of ashes, on incineration, and that these ashes are composed of 0,393 of phosphat of lime, and 0,607 of pure filix. This chemist looks upon it as somewhat extraordinary, that he did not find any mixture of alcali or calcareous earth with the phosphat and filix.

Having determined the nature and proportions of the earthy matters contained in oats, he was desirous of knowing the changes these earths had undergone by digestion. On which account he enclosed a laying hen in a place, and gave her oats, of which he knew the weight. In the space of ten days, the hen had eaten 483,833 grammes of this feed, and had laid four eggs.

Residuum  
of hen dung  
produced  
by oats and  
burnt.

Having collected and dried the excrements, he incinerated them in a crucible of porcelain, and found the ashes to weigh 38,957 grammes. These ashes were in part dissolved by the muriatic acid without effervescence, but there arose a strong odour of sulphureous hydrogenous gas. When the acid had ceased to act on the matter, it was diluted with water, filtered, and the residuum edulcorated, it weighed 8,492 grammes; some caustic ammonia was then poured into the muriatic solution, which formed a very abundant white precipitate, and weighed, when washed and dried by a read heat, 7,643 grammes. This matter submitted to different experiments presented all the characters of phosphat of lime, without any mixture of foreign matter.

The liquor (separated from the phosphat of lime) mixed with the common carbonat of potash, gave a white precipitate in large quantity, which weighed 2,547 grammes when dried.

The formation of a considerable quantity of carbonat

Remarks.

of lime that did not exist in the oats with which the hen was nourished, is a circumstance very important both with respect to the theory of the formation of the shells, and for the economy of granivorous animals in general. It is not less remarkable, that the quantity of phosphat of lime obtained in the excrements of the hen, furnished by 483,838 grammes of oats, is much greater than what the same quantity of oats afforded by combustion, which out of 15,285 grammes of residuum, gave 5,944 grammes of pure phosphat of lime. Hence it would appear, if the experiments of Vauquelin are exact, that,

1. A portion of lime was formed during the act of digestion, and of the animalization of the oats.

2. That a portion of phosphoric acid was likewise formed.

3. That a certain quantity of carbonat of lime was equally generated.

In reality, 2,547 grammes of this last substance were obtained from the excrements of the hen, whilst the oats afforded none; and besides, the hen laid four eggs during the time of eating the oats, the shells of which weighed about 19,744 grammes, which with the 2,547 remaining in the excrements, form 22,291 grammes, or five drachms, six grains; a very considerable quantity. It cannot, however, be supposed that this carbonat was formed at the expense of the phosphat of lime contained in the oats, for it is to be recollected, that only 5,944 grammes were obtained from 483,838 of this feed, and that the excrements arising from the same quantity of oats gave 11,944, which makes a difference of six grammes.

Thus the excrements of a hen which had only eaten 483,838 grammes of oats, in ten days, afforded on ana-



lysis 2,547 grammes of carbonat of lime, which added to the 19,743 grammes, forming the shells of the eggs laid during the interval, make 22,29 grammes, of which not a particle exists in the oats.

They likewise furnished 11,944 grammes of phosphat of lime, whilst 483,838 grammes of oats only gave 5,944. Hence there was an increase of six grammes; a very considerable quantity.

Vauquelin endeavoured to find, in the residuum of the burnt excrements of the hen, insoluble in acid, the origin of this carbonat of lime, which is not found in oats, as well as the increase of the phosphat of lime, a part of which only exists in that feed. Quantity of flex in the cats with that in the excrements.

For this purpose he took the 8,492 grammes, or 160 grains of residuum, (left after the muriatic solution was diluted) as before mentioned. These were formed with three parts of caustic potash, in a silver crucible, and after being properly treated, 8,067 grammes of pure nitre were extracted from them.

The 0,425 of a gramm deficient must be attributed to the carbonated matter that coloured the residuum.

On comparing, therefore, the residuum of the excrements of the hen with that of the oats, respecting the flex, it appears that it contains 1,274 gramm less of flex, since 483,838 grammes of oats furnished 9,342 grammes of this earth, whilst the excrements arising from the same quantity of this feed only afforded 8,067 grammes.

It appears from these experiments, that whether the small quantity of flex found in the nutriment of the hen, gives rise to the calcareous matter of the excrements or not, it is certain, that a considerable quantity of lime, both in a state of carbonat and phosphat, is generated in the organs of that animal, whilst a portion of flex is found to have disappeared, which seems to

be in too inconsiderable quantity to give origin to so great a mass of calcareous earth, (the filex being only 1,274 gramm, the calcareous matter 14,118 gramms). But although the conclusions are little satisfactory, the results of the experiments merit a farther consideration; and should future ones confirm them, it will oblige the chemist to admit, that filex is changed into lime during the digestion of poultry.

Macquer's Chém. Wœrterbuch von Leonbardi. p. 134, t. 2.—Fourcroy's *Système des connaissances chimiques*, &c. par A. F. Fourcroy, Art. Meconium, t. 10. Paris, An. 11.—*Expériences sur les Excrémens des Poules, comparées à la Nourriture qu'elles prennent, et Réflexions sur la Formation de la Coquille de l'Œuf*, par le Cit. Vauquelin, *Annal. de Chimie*, p. 3. tom. 29. An. 7.

## COMPONENT PARTS.

ON taking a view of the analysis of the different parts of the animal body, and particularly that of the fluids, solids, hard and external parts, it appears from the preceding experiments, that besides water, which is more or less common to all bodies, there are four principal substances that predominate in their composition, and it is from these more particularly, that the different organs have their origin. These four substances are, albumen, gelatin, fibrin, and osseous matter; and the following are their characters and properties, according to chemical analysis.

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 ALBUMEN.

Animal albumen is generally found in the form of a transparent fluid, more or less viscous, and of an aqueous colour, tending to a yellow.

It's flavour is slightly saline, and if tasted with attention, somewhat sharp. It's properties.

It changes the sirup of violets green.

It is soluble in cold water.

Alkalis dissolve it.

Acids coagulate it.

Lime water produces a precipitation in the albumen, which is the phosphat of lime. It is coagulated by the metallic oxyds, and by alcohol.

It decomposes; and causes a precipitation in solutions of neutral, calcareous, and metallic salts.

It undergoes the putrid but not the acetous fermentation.

The most distinguishing character of this fluid is, that when exposed to a degree of heat from  $45^{\circ}$  to  $48^{\circ}$  ( $50^{\circ}$  being the boiling point) it's liquidity and transparency disappear, it becomes opaque, white, concrete, and solid.

On examination, during this change, there is a fibrous appearance, but as soon as the coction is complete, the whole is homogeneous, white, and solid; and on exsiccation, it is brittle, shining in it's fracture, and transparent. A great degree of heat disengages ammonia from it, and a very fetid oil, as from other animal substances.

Oxygenated  
albumen,  
it's properties.

This concretion of albumen by heat is, according to Fourcroy, one of the most remarkable phenomena, animal substances present to the chemist; and from a number of experiments made upon it, with Vauquelin, he attributes it to the absorption and fixation of oxygen, for which the heat increases it's affinity. In this state he calls it oxygenated albumen. It is then of a white colour, and has changed it's properties; for, according to Fourcroy, solid or oxygenated albumen is no longer soluble in water; Hatchett, however, found, that in a slight degree, inspissated albumen is soluble. It is insoluble, however, in caustic alkalis.

Concentrated acids produce different effects upon it. The concentrated sulphuric acid reduces it to a charcoal by combustion, during which a disagreeable odour is emitted. The nitric acid at the temperature of  $15^{\circ}$  disengages azot gas from it, and if the mixture be heated, prussic acid is formed, flying off in the form of a gas, recognized by the odour of bitter almonds; afterward a portion of the charcoal is separated, which united to it's oxygen forms carbonic acid gas: when the disengagement of these two acids has taken place, the nature of the albumen is singularly changed, it's constituent prin-

ciples no longer retain the same order or proportion in their composition; the result of which is, on the one side, the oxalic acid, on the other, a fatty or oily matter, of a citron colour, that swims in the same liquor; a green little malic acid is also obtained.

If the albumen coagulated by acids be diluted with water, the liquor filtered and evaporated, salts are obtained, the basis of which is soda; hence the cause of the colour liquid albumen gives to violets.

It is also to the same salt, as well as to the phosphat of soda and ammonia, found by analysis to exist in albumen, that the precipitation of the above mentioned different salts arise. According to Fourcroy, the metallic precipitates carry with them a portion of it in it's oxygenated and concrete state. It is likewise by decomposing the phosphat of soda, which is held in solution, that the precipitation by lime is produced.

By gently evaporating the water in which albumen has been diluted, after having obtained this last in a concrete form by heat, and separated it from the lye, crystals of muriat of soda are obtained. To this it may be added, that it is often observed, on treating in this way several species of albumen, and amongst others the serum of the blood, and that which exists in the muscles, and is extracted by pressure, that the liquor when properly evaporated, to obtain the crystallizable salts, becomes a jelly, on cooling: this phenomenon is only indicated here to show, that the liquid albumen is often accompanied with another animal substance of equal importance; an account of which will be given in the next article, *Gelatin*.

From the analysis of albumen, it appears to be composed of carbon, hydrogen, azot, and different proportions. It's composition.



tions of oxygen, phosphoric and muriatic acids, soda, and lime.

Remarks  
upon albumen.

The name of albumen has been given to this matter, from it's analogy to the white of an egg, and in whatever part of the body it is formed, it's characters are invariably the same. This organic composed substance is very abundant in all animals, and forms a very distinct genus amongst the composed parts of organized bodies. The white of the egg, called albumen by the Latins, may be looked upon as the first species of this genus; and it was that, the analysis of which was first the means of discovering the striking analogy that exists between it and many other animal substances. The serum of the blood, the more or less thick and even concrete matter of the vitreous humour, and of the crystalline lens, a great part of the white humour which moves in the lymphatic or absorbent vessels, the water collected in the different cavities of the body distended by the dropsy, are the principal species of this genus; or to use a more exact method of expression, contain a very large proportion of albumen; whilst the greater part of the membranous and white organs, and especially the membranes which line the hollow viscera, as well as silk, contain more less of it in it's concrete state: in short, it is found even in the juices of vegetables. It's liquidity arises from it's always being combined in the fluids, of which it forms the principal basis, with a certain quantity of water; but on becoming an integrant part of the solid organs it is in a concrete state, and has in some measure changed it's nature and properties. It is certain, that the degree of heat, by which it is coagulated by chemical agents, cannot take place in the body, yet the formation and separation of most of it's organs require the slow fixation of oxygen, the combination of which, with the animal fluids, appears from the ex-

periments on respiration to take place in the lungs. It is, therefore, during it's circulation in the sanguiferous and lymphatic vessels, that the albumen absorbs by degrees the oxygen, until it has received such a quantity as to become concrete, which appears to be at the time it has arrived in the ultimate vascular ramifications which carry the nutriment to the solids ; hence the necessity of changing it's nature, and instead of remaining liquid, to become concrete or oxygenated albumen ; and as the variable quantities of the oxygen and water depend on the age and state of health of animals, they produce a more or less strong concrescibility, or more or less decided fluidity of the albumen.

Albumen, according to the experiments of Hatchett, is the predominant and essential part in the tissue, or web of membrane, cartilage, sponge, the horny stems of gorgoniæ, horn, hair, feather, quill, hoof, nail, horny scale, crust, and tortoise-shell ; and although in all it has similar chemical properties ; yet in consistence, it varies from a tender jelly-like substance, to a completely formed membrane, or to an elastic, brittle, hard body, like tortoise-shell ; and he thinks, it is the original substance from which all these bodies as well as muscular fibre derive their origin. He affirms, there is also much reason to believe, that gelatin, although it appears so different in many respects from albumen, is yet formed from it : for, from his experiments, it appears, that tortoise-shell, horn, muscular fibre and inspissated albumen, after long dilution in very dilute nitric acid, and after being well washed, were soluble in boiling water, and that a substance was formed, which (by becoming liquified when heated, by being soluble in boiling water, by being precipitated by the tanning principle, and by nitro-muriat of tin ; and lastly, by forming a gelatinous mass, when the aqueous solution was sufficiently

evaporated and cooled, approached and resembled gelatin. He thinks it might perhaps be too hasty to assert that gelatin was absolutely thus formed; but if a substance so very similar to it could be thus produced, he is of opinion, that the real gelatin, with it's various modifications, is formed from albumen, by the more efficacious and delicate operations of nature.

In attempting to prove that albumen, or the coagulating lymph, is the original animal substance, this chemist has only stated chemical facts; but when the phenomena attending incubation are considered; when the experiments made by eminent physiologists, such as Haller, Maitre Jean, and Malpighi, are attended to; when the oviparous foetus is seen to be progressively formed in and from the albumen of the egg, so that upon the bursting of the shell which separated it from external matter, the young animal comes forth complete in all it's parts; when such strong facts as these are corroborated by those which chemistry affords; it can scarcely be doubted, according to Hatchett, but that albumen is the primary substance from which the others are derived; and there is much reason to believe that the formation of gelatin, and of the animal fibre especially, begins with the process of sanguification in the foetus.

This is by no means a novel opinion. It was supposed by Thöuvenel, that animal albumen might be converted into animal jelly; and Fourcroy affirms, that gelatin only differs from albumen by containing a larger proportion of oxygen, and that since gelatin has a great tendency to become acid, it is a proof of it's having a greater quantity of oxygen in it's composition, which was only necessary to form that fermentation. This chemist is more particularly confirmed in his opinion, by finding that all vegetable substances which are acid, and fruits in particular, contain no albumen, whilst gelatin is con-

stantly obtained; on the contrary, those which afford albumen, as all young vegetable substances do, show no appearance of acidity. He has also observed, that the albumen of the blood forms with the nitric, muriatic, and acetous acids, a species of gelatin. Hence he suspects that every jelly is a combination of the oxygenous principle and albumen. Such are the opinions of the present chemical physiologists on the conversion of albumen into gelatin.

From the properties which albumen possesses of being coagulated, it is made use of in the arts to clarify various fluid bodies. For this purpose, the blood of different animals is in general chosen, when any large quantity of clarifying albumen is wanted, this fluid containing it in large quantity, and being easily procured. When required in small quantity, the albumen of the egg is generally preferred as being more delicate. It acts by uniting with, and entangling in it's composition as it coagulates, the impure parts of the fluid to be clarified, which it carries to the surface in the form of a hard scum, which being no longer soluble in it's coagulated state, is easily taken out. This coagulating property is likewise of use in the art of anatomy, for when it has undergone this change by the muriatic or nitric acids, any heterogeneous parts it contains are more easily to be discerned. It was thus, that Reil discovered the nerves of the crystalline lens, and when those worms which are denominated gelatinous have been immersed a few seconds in either of the above acids, a fibrous structure is observed, and the anatomist is enabled to distinguish and examine them.

## GELATIN.

It's properties.

ON boiling animal substances in water, a certain matter is extracted, which, on becoming cool, forms a solid and tremulous jelly, and from this property it has been called gelatin.

When pure, it is colourless and transparent, without smell, and of a mild flavour. It is perfectly soluble in water, but does not coagulate as albumen does. It is likewise soluble in acids and alkalis, but less so in the last. With the nitric acid, a little azot is disengaged, and a small part is changed into fat, whilst the greater part is converted into oxalic acid. Solutions of lime produce a precipitate of phosphat of lime when poured into a solution of gelatin. With the principle of tan it forms a compound insoluble in water; hence this principle is a very convenient reagent to ascertain the presence of gelatin in any fluid, and to determine with precision quantity. Thus, if the infusion of tan be poured into milk, whey, serum, broth, &c. it forms a precipitate more or less abundant, according to the quantity of gelatin they contain. It is insoluble in alcohol. If kept for some time, it undergoes the acetous fermentation from the saccharine matter it contains; and this is said sooner to take place in the gelatin of graminivorous animals; it afterward passes into the putrid fermentation, and gives carbonated ammoniacal gas.

By distillation in the water bath it affords an insipid, inodorous phlegm; in proportion as it loses its water, it assumes the consistence of and becomes *glue*, for which, vide *Soft Parts*; and when entirely dried, it resembles horn. Exposed to a stronger heat with access of air, it swells, liquifies, and becomes black, emitting a great deal of



fetid smoke, which does not easily inflame. By a violent heat in a retort, it affords an alkaline phlegm, an empyreumatic oil, and a small quantity of ammoniacal chalk; and leaves a large mass of charcoal of difficult incineration, containing muriat of soda and calcareous phosphat.

The component parts of gelatin are, therefore, carbon, hydrogen, azot, saccharine matter, phosphoric acid, muriatic acid, lime, and soda. It's composition.

Gelatin is obtained from all the soft and white parts of animals in large quantity, such as the membranous parts, tendons, ligaments, aponeuroses, cartilages, horns, bones, and skins. It therefore appears to partake of the solidity of albumen in most of these parts, and as it forms the basis of all of them, they are more or less susceptible of being dissolved by boiling water, and of forming transparent jellies on becoming cool. From experiments, it appears, that gelatin in most of it's properties bears a great resemblance to those of the insipid vegetable mucilages, if we except those that afford ammonia by heat and mephitis by the nitrous acid, which, from the opinion of Fourcroy, may be attributed to a portion of lymphatic matter or albumen, which the water extracts at the same time with the gelatin, particularly when jellies or glues have been prepared by strong decoction, long continued. Remarks upon gelatin.

According to Hatchett, gelatin varies in it's degree of consistence, and in making experiments on animal substances, he had frequent opportunities of observing the various degrees of viscosity and tenacity which characterize it, and which he has noted by the different names of mucilage, size, and glue. In young animals the mucilage is more predominant, and it becomes diminished as they increase in growth and age. Hence there is every reason to conclude, that the substance, which in very

young animals was at first mucilaginous, becomes progressively more viscid, and assumes the characters of gelatin; mucilage is, therefore, the most attenuated, and the lowest in order among the modifications of gelatin. Gelatin, he found, whether in the state of mucilage, size, or glue, when completely dried, to be affected by water according to it's degree of acidity, and examined by the tanning principle, and nitro-muriat of tin; mucilage is more immediately affected by the latter than by the former, while the solutions of size and glue are equally acted upon by both. When these three varieties are steeped in nitric acid, with three or four parts of water, they also progressively dissolve according to the degree of viscosity by which they are separately distinguished. Gelatin, according to it's quantity and quality, has a powerful influence on some of the physical and chemical properties of the bodies in which it is present, viz. on their flexibility, elasticity, and putrescibility; for when bodies, such as muscular fibre, membrane, sponge, hair, and cuticle, are deprived of gelatin, and dried in the air, they become rigid and brittle, and Hatchett has no doubt, but that this arises from the loss of the gelatinous substance; and as an additional proof, when bodies, such as nail, feather, quill, and tortoise-shell, which contain little or no gelatin, are long boiled, and then dried in the air like the former, they are found to have scarcely suffered any alteration in their respective degrees of flexibility and elasticity. As to putrefaction, it is obvious that certain parts are more susceptible of it than others, thus the viscera, muscles and cutis, soon suffer a change; while hair, feather, scale, hoof, horn and nail remain unchanged for ages after the former have been decomposed; the cause of this he attributes to the gelatin and moisture, which are combined in the former, and not in the latter in any notable quantity; for mucilage dissolv-

ed in water, he found to be the first, and glue the last that showed symptoms of putrefaction. It is, therefore, the presence of gelatin in various states and proportions (including moisture and organic arrangement) that is the principal cause of those degrees of flexibility, of elasticity, and of putrescibility, so various in the different parts of animals.

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#### FIBRIN.

THE fibrous part of animals, when pure, is of a white colour, without smell or taste; it is very tenacious, and capable of being lengthened. It is procured in this state by washing the coagulated part of blood, when it remains in the form of white filaments of a very solid consistence. It is insoluble in water at all temperatures, and when boiled it hardens, and assumes a gray colour. The most weak acids dissolve it. Diluted nitric acid, according to Berthollet, disengages a larger quantity of azot gas from it than from any other animal substance, and by the aid of heat, it dissolves it with effervescence, accompanied with nitrous gas; when all this gas is disengaged, oily and saline flocks are observed in the residuum, floating in a yellowish liquor, which, on evaporation, affords crystals of oxalic acid, and a larger quantity of flocks, composed of a fatty matter, and phosphat of lime is deposited. Concentrated sulphuric acid converts it partly into water, partly into acid. The muriatic acid dissolves it, and forms with it a green jelly. The acetous likewise dissolves it by the aid of heat. The fibrin is precipitated from the acids by the means of water, and more particularly by alkalis. During this combination with the acid, the fibrin is decomposed, and when separated, no longer

It's properties.

presents the same properties. It is not dissolved by alkalis in their diluted state; but when caustic and concentrated, they attack it by the means of heat. Neutral salts, and mineral substances, have no effect upon it.

On being exposed to distillation, it affords water of a faint smell, an alkaline phlegm, a ponderous, thick, and very fetid oil, with much ammoniacal chalk. The remaining coal is not bulky, but compact and heavy; and is less difficult to incinerate than that of albumen. The ashes are very white, and contain neither saline matter, nor iron; their appearance being earthy, seem to consist of phosphat of lime.

The most gentle heat suddenly affects fibrin; it shrinks into a substance resembling parchment, and when exposed to a strong heat, becomes like a piece of horn or bone; on being burnt, it crackles, and produces a very fetid smell like the burning of feathers.

It putrefies with great facility, and being exposed to a hot and moist air, swells, and affords a large quantity of volatile alkali.

The only parts that contain fibrin are the blood and the muscles; in the first it would appear to be in a state of solution, or at least in a very divided state, but possessing the remarkable property of becoming concrete on cooling and repose, in which a fibrous texture is afterward very evident. In the second, it is condensed, concreted, or perhaps to use a more appropriate expression, organized under the form of muscular flesh; which, according to Fourcroy, ought to be considered as the real reservoir of all the fibrin contained in the blood. In this view he looks upon the muscles as certain organs, in which this animal matter is deposited, so as to constitute their basis, forming the substance that is most eminently irritable.

Fibrin, therefore, differs greatly from albumen; it is a

kind of animal gluten, greatly resembling that of flour, and is more perfectly animalized than either albumen or gelatin, from it's possessing so great a proportion of azot. There is, however, reason to believe, that the principal difference between it and gelatin arises from it's containing a greater quantity of oxygen; and that the vital power, by causing the gelatin to combine with a larger proportion of the oxygenous principle, converts it into fibrin, or oxygenated gelatin: this conclusion is greatly supported by the observation of Seguin, who affirms, that substances capable of absorbing oxygen deprive the fibrous matter of it's solidity, and convert it into gelatin.

From the experiments of Hatchett, it appears, not only that albumen, gelatin, and fibrin, differ very much from each other in their relative proportions of saline or earthy residue, but also in the proportion of one of their essential elementary principles, which is carbon; and as in vegetables the fibrous part contains the largest proportion of carbon, so in animals, muscular fibre appears to contain the greatest quantity of it. It likewise far exceeds the others in it's proportion of azot. These three are however easily separated from each other by boiling water, whenever a substance containing them is exposed to it; the gelatin is dissolved, and may be precipitated by tan, the albumen is coagulated, and the fibrin remains unaffected.

From these three substances, *albumen*, *gelatin*, and *fibrin*, in a state of concretion, either singly or forming double or ternary combinations, and more especially from their different proportions, the organs of animals are formed. They likewise compose a great part of the animal fluids, particularly the albumen; in these, however, there is less oxygen and more water, and they are besides united with acids, neutral salts, phosphat of lime, &c. Gelatin is very sparingly found in the fluids, but abounds in the

Form various combinations.



solids, and it appears to receive it's gelatinous nature on passing from the first into the last. It is also more abundantly found in young animals ; on the contrary, age is more adapted to the formation of fibrin, old animals containing a greater proportion of it. It is, however, the albumen that appears only to undergo any particular alteration from disease, at least in the blood. Parmentier and Deyeux affirm, that this change in the albumen became particularly sensible in the serum, which in a state of disease never acquired that complete concretion on exposure to heat, which always took place in healthy serum ; but a certain quantity of liquid separated on simple decantation. The morbid action had no influence in these cases upon the gelatin or fibrin.

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#### OSSEOUS MATTER.

THE fourth substance that is joined to the above three in various parts of animals is the osseous matter ; it forms a considerable part of the animal body, particularly of the solid organs, and is the great basis of support to the animal fabric. In young animals it is in small quantity, but increases in proportion to the age ; and when an animal has obtained it's proper proportion of this osseous matter, it's organization is completed, whilst as age advances, a superabundant quantity is deposited in almost every part of the body, giving rise to the rigidity of the different organs ; and as the fibrin in some measure gives place to it, the functions become greatly impaired ; hence what was wanting to add solidity in infancy, and produce it in the adult, in old age, by it's great accumulation, renders the system incapable of acting with it's accustomed agility. Of all the parts of the body the bones

contain the largest quantity of this matter, whence it has derived it's name of *osseous*; the original texture of these organs being membranous and porous like a sponge, the osseous matter is deposited in it, forming those hard pillars that support all the other parts of the animal machine. It is not, however, only present in the bones of man, quadrupeds, and birds, but also in those of fish, and even in the skeletons of insects. This osseous matter is an earthy salt, or the phosphat of lime, a nearly insoluble substance; for an account of which, vide *bones*.

The component parts, therefore, of animal substances, may be divided into two kinds, the proximate, and remote. Component parts, two kinds of.

1st. The proximate parts, or those matters that may be separated from animal substances, without their organization suffering much change, are albumen, gelatin, fibrin, oils, acids, poisons, aromas, and colouring parts. 1. Proximate parts.

2d. The remote parts, or those ultimate component parts into which the proximate parts are decomposed, and beyond which chemical analysis has not been able to penetrate, are oxygen, hydrogen, carbon, azot, soda, sulphur, phosphorus, lime, and iron; and it is from these in different proportions and combinations, that the very complex machine of animals is formed. 2. Remote parts.

On comparing animals with vegetables, they appear to be only a gradual series from a more or less perfect system of organization; and although the one may be easily distinguished from the other, in their more perfect forms, yet as we descend towards those tribes that have been said to form the limits between the two kingdoms, the difference seems to vanish by degrees, and the animal organization is lost in that of the vegetable. There is great reason to believe that this change, which is for the most part external and physical, is equally gradual with Animal substances compared with vegetable.

respect to their component parts, so that their chemical analysis may in great measure corroborate the observations of the natural historian.

Difference  
between  
their prox-  
imate prin-  
ciples.

The difference that exists between the proximate principles of animals and vegetables consists either in their proportions or their varieties; thus

1st. Albumen in animals is found in large quantities, whilst the juices of vegetables contain very little of it.

2d. Gelatin in animals is much softer, not so easily dried, and has a stronger taste than in vegetables; it likewise attracts humidity from the air, and is more disposed to putrefy than in the last.

3d. Fibrin, in animals, though analogous to the gluten of flour, has more tenacity, and they contain it in larger quantity.

4th. Fixed oils, in animals, are more concrete, and more abundant than in vegetables; and, according to Berthollet possess different characters, for animal oils give, on distillation, an alkaline liquor, whilst the vegetable give an acid; on the contrary, the volatile oils and resins are more abundant in the vegetable tribes.

5th. Acids appear to form a great difference between the two kingdoms: for although some of the vegetable acids, as the oxalic, malic, benzoic, and acetous, are found in animals; and some of the animal acids, as the sebatic, the prussic, and the phosphoric in vegetables; yet they are in very small quantity, and the bombic, the formic, the lithic, the lactic, saccholactic, and the amniotic, are peculiar to animals only. The alkalis likewise are different; in the animal soda prevails, in the vegetable potash is predominant.

6th. Poisons are less abundant in animals than in vegetables, and their action is only on the blood, whilst vegetable poisons act on the stomach. Animal poisons likewise dispose the body to a more rapid putrefaction.

7th. Animal aromas are less agreeable, and less various than those of the vegetable kingdom.

8th. Animal colouring parts, on the contrary, are much more splendid and beautiful than the vegetable ones.

9th. The difference in their remote parts likewise appears to arise more from their proportion than any new principles; but since it is in these that chemists have founded the distinguishing characters, it will be necessary to give it more in detail.

The difference that constitutes the essential character between animal and vegetable substances, when subjected to analysis, was but very imperfectly understood before the experiments of Berthollet, to whom we are principally indebted for what is known on this subject. It had, indeed, been observed, that the action of fire, which was almost the only chemical agent to which animal substances had been submitted, gave rise to products that were much more disagreeable in smell than what arose from vegetables, and that the stench produced from them during putrefaction was likewise equally intolerable; but even Neumann, one of the most enlightened of the chemists of his time, seems not to have been aware of the principle that constitutes the chief distinction, or of the origin of the disgusting and nauseating effluvia.

Between  
their remote  
parts.

Ignorance  
of the old  
chemists.

It had been observed by some chemists, that animal substances were not, however, the only matters whose spontaneous or artificial analysis by fire was so intolerable; but that certain vegetables, particularly of the cruciform tribes, greatly resemble them. Hence Boerhaave divided plants into two classes; in the *first*, he placed those which afforded by distillation water, an empyreumatic acid phlegm, a little carbonat of ammonia, and a charcoal. In the *second*, those which afforded a fetid water, a very fetid empyreumatic oil, carbonat of

ammonia, both in a dry and liquid form, and a charcoal of difficult incineration. The products of the last, it is evident, made them approach very near to those which animal matters afford, and on this account they were called by Rouelle animal plants, as partaking of the animal nature; they form by much the smallest class, comprising most of the acrid plants, such as tobacco, sneezewort, garlick, onions, mustard, horseradish, and all the cruciform plants, except the *crambe tataria*; the mulberry likewise belongs to this class. Beccaria discovered a substance that is nearly animalized in flour called gluten; and it was found, that phosphorus, which Margraaf had already discovered in plants, always made a component part of them.

Reason of  
it.

Chemists were, however, still ignorant of the reasons of these differences, and it may be easily accounted for, on considering how little they were acquainted with the action of reagents on organized matters, and more particularly from their want of knowing the nature of the gaseous fluids, for the discovery of the properties of which modern chemistry is so justly celebrated. Conjecture, however, supplied the place of facts; and it was attributed to the greater proportion of phlogiston, and its less firm combination with the other principles of animal

Discovered  
by Priestly.

matters than of vegetables, until Priestley made the discovery. He found, on treating vegetables with spirit of nitre, that besides fixed air nitrous air was produced. On the contrary, animal substances treated in the same manner, instead of nitrous, afforded *phlogificated air*. Berthollet, taking advantage of this discovery, and extending his researches on the subject, found, that on estimating the results that arose from the analysis of animal and vegetable matters, the principal difference between them was really owing to the air which Priestley had called phlogificated, and which he named, according to the new theory, azot

Applied by  
Berthollet.  
Azot forms  
the great  
difference  
between the  
animal and  
vegetable  
world.



gas. Hence to the presence and proportion of *azot* in animal substances, and to the great quantity they in general contain are to be attributed,

1. Their property of affording a much larger quantity of ammonia than vegetables, and of giving such very fetid products.

2. Of affording a much larger quantity of *azot* gas, particularly when treated with the nitric acid.

3. Of affording a great deal of prussic acid.

4. Of contributing singularly to the formation of the nitric acid, while the remaining remote parts of organized beings contribute to make their division and difference still more evident; thus,

5. Oxygen, which is in very small quantity in animals, abounds in vegetables; on the contrary,

6. Hydrogen, phosphorus, and sulphur, are more abundant in animals, and it is from the different proportions of these parts that

Animals are more subject to the putrid fermentation;

Vegetables, to the spirituous fermentation:

Animals afford an alkali;

Vegetables an acid:

Animals have a coal of difficult incineration;

Vegetables, of easy incineration.

The predominancy of the quantity of *azot* in animal substances is therefore looked upon by chemists as the efficient cause, that more particularly distinguishes them from vegetables, more so than the greater or less proportion of any of their other remote parts; the simple vegetable is even said to be entirely without it, and to consist, according to Lavoisier, only of the three principles, oxygen, hydrogen, and carbon, *azot* being only present in those vegetables that are more or less animalized. *Azot*, however, exists in different proportions, even in animals. Gelatin affords the least quantity of it; albumen has it

in larger proportion; but of all the parts of an animal, the fibrin affords the most. It differs likewise, according to the age and species of the animal; thus the flesh of young animals affords less than that of old, the difference amounting even to  $\frac{1}{3}$ . The flesh of carnivorous animals gives somewhat more than that of the frugivorous class; fishes afford it more readily than quadrupeds, and it always is perfectly correspondent to the quantity of ammonia produced by the action of fire.

*Conclusion.* From this principle being wanting in vegetables, it may be concluded, that if animal matters be deprived of it, they will, in some measure, be brought back to the state of vegetable matter; and that to animalize the last, it is necessary to add azot: and this is effected by nature, in the first instance, in the decomposition of animal bodies by putrefaction; and in the second, when she composes them by animalization. Chemistry, less perfect than nature, has arrived at present only at the means of performing the first process, or of reducing them to a less complex state by analysis; to compound them again, or produce animal matters from vegetables by synthesis, she has at present been utterly incapable, the principle of life not being at her disposal.

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## APPENDIX.

THE parts of animals hitherto examined have, with very few exceptions, been taken from the human subject, and those animals which Daubenton has placed amongst the quadrupeds, and there now remains to give an account of the products that have been extracted from oviparous quadrupeds; serpents, insects, and worms. The imperfect manner in which the analysis of these four last classes has been made, prevents their being introduced in the preceding division; for, as in general, the whole animal has been the subject of the process, it would be impossible to ascertain to what particular part the products obtained ought to be attributed.

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 OVIPAROUS QUADRUPEDS AND SERPENTS.

Oviparous  
quadrupeds  
and ser-  
pents,

THESE animals have in general a stronger odour or smell than the parts of that class of quadrupeds already examined; they are found to contain a much larger proportion of saline matter, affording a large quantity of volatile alkali, after having been triturated with oil of tartar, and submitted to distillation by a gentle heat. Amongst these, the tortoise, the frog, the toad, the lizard, the viper, and the snake, have been employed in medicine, either by regular practitioners, or by quacks; and great virtues have been attributed to them in the cure of different diseases, but a more experienced age has nearly exploded their use.

It appears from the experiments of Thouvenel, that these animals, on analysis by heat, afforded a jelly which was more or less light and viscous; a pungent, bitter, and deliquescent extract; an albuminous concrescible substance; an ammoniacal salt; and an oily substance of a peculiar taste and smell, part of which was soluble in alcohol.

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## INSECTS.

Insects.

### ANTS.

THIS industrious animal, so noted for the care of it's Ants. eggs, by conveying them to receive the warmth of the sun, and carrying them off on his disappearance, or on the approach of rain, and so much celebrated for it's republican mode of government, has already presented a peculiar acid to the chemist, called the *formic acid*; it now remains to give an account of it's other properties. It appears to be an omnivorous animal, living on grain, the sweet juices of vegetables, and the fleshy parts of animals. From this last circumstance, the anatomist is furnished with an assistant, by which he may obtain the skeletons of small animals, worked in an exquisitely neat, beautiful, and perfect manner, and far surpassing any thing than can be executed by the art of man. The animal, whether frog or mouse, must be enclosed, for this purpose, in a wooden, or other box, perforated with a number of holes, and placed in or near an ant-hillock; and it will be found, that in a few days every part of the animal will have been devoured except the bones and ligaments.

This animal has been supposed to furnish a substance



of a resinous nature, formerly used in medicine, and thought to possess peculiar virtues; it is found in pieces, on searching the ant-hill, and was distinguished by the names of wild frankincense, *suffimentum silvestre*, thus *germanicum*, *massix*, and *electrum formicarum*; but on a more exact examination, it appears to be nothing else than the common resin of the fir, at the roots of the old trees of which these animals generally lodge; their reason, however, for collecting it, is unknown. According to Neumann, ants are destroyed by strewing a large quantity of unslacked lime about their hills.

Neumann, in his analysis of this insect by heat, distilled two parcels in a retort; the one consisted of ants, from which water had been previously extracted in *baln. mar.*, then exsiccated; the other parcel was composed of fresh ants. Twenty-four ounces of the first afforded him four ounces and half of empyreumatic oil, three ounces and half of urinous spirit, two drachms and half of concrete volatile salt, one drachm of fixed alkaline salt, and eight ounces of earth; whilst no acidity was observed during the process. The same quantity of the second afforded eleven ounces two drachms of an acid spirit, six ounces six drachms of an urinous spirit, one ounce and half of empyreumatic oil, one drachm and half of concrete volatile salt, and nearly three ounces of earth remained, which gave half a scruple of fixed salt. Another circumstance, besides that of the total elevation of the acid by distillation, even in *baln. mar.*, occurred to this chemist, for having extracted some spirit of wine from a quantity of ants, and cohobated the spirit upon two or three fresh parcels, he found swimming upon the distilled liquor a fine, clear, essential oil, a phenomenon extremely rare in the animal kingdom, and which was corroborated by obtaining the same by distillation with water. This essential volatile oil, obtained by digestion

with the spirit of wine, forms the spirit of magnanimity of Hoffmann. This æthereal oil was already known to Sperling. Margraaf likewise obtained it; but Rouelle was scarcely able to observe a trace of it; twelve ounces only gave him a drop. Hermbstadt, on distilling sixteen ounces of ants with three times the quantity of water, obtained one drachm six grains of it. According to Thouvenel, ants on analysis afford products similar to bodies from the vegetable kingdom. 1st. A very sharp volatile acid. 2d. A volatile oil, resembling the essential oil of plants. 3d. A fat oil, which is not attacked by alcohol, and resembles fat vegetable oil. 4th. An extractive matter, partly soluble in water, partly in alcohol. 5th. A web or shining substance, without taste or smell, which slightly tinges spirit of wine, and the nature of which is not known.

From the experiments on ants, it appears, that they consist of an acid, which is very volatile; an essential oil extracted by alcohol in very small quantity; a fixed oil, three drachms of which are extracted by boiling, and then pressure, from one pound of ants, which is of a greenish yellow colour, congeals at a much warmer temperature than olive oil, and which resembles wax; and an extract: this last is taken from the evaporated decoction, is of a reddish brown colour, has a fetid odour, is acid, bitter, and nauseous to the taste, of a caseous consistence, and is separated into two parts by the successive application of water and alcohol. The parenchyma of the animal, deprived of these substances, amounts nearly to three ounces two drachms per pound.

## CANTHARIDES.

THIS species of insect is well known from it's stimulating property of raising blisters, and hence it is employed in the practice of medicine. It is of a bright shining, greenish, golden colour, with a blueish hue. Cantharides were formerly brought from Spain, and hence obtained the appellation of Spanish Flies, but they are produced in great numbers in France, Germany, and other parts of the continent. It is principally from the ash and the poplar they are collected. The usual method of killing them, according to Neumann, is by the steam of distilled or strong vinegar; but Lewis observes, that vinous spirits, as they are used for the curation of millepedes, are much better calculated for the destruction of cantharides, as well as of all other insects; for the steam of alcohol, or the liquor itself, when sprinkled upon them, is not only an immediate destroyer, but has likewise the property of preserving them from decay. The flies are afterward dried, and made into parcels, so as to be secured from the air. By long keeping, however, they fall by degrees into a grayish or brownish powder, and in this state are unfit for use, their intrinsic quality being found to perish with their external form. The most durable are the wings, which remain entire after the body of the insect has mouldered into dust.

Cantharides, when fresh, have a strong fetid smell; when applied to the tongue, they make no impression upon it, but in a short time a degree of acrimony and a kind of pitchy taste are discovered. Applied to the skin, they raise a blister upon the part. The stimulating power of this insect has been attributed to an acrimonious caustic salt; but according to Neumann, experiment does

not discover any saline principle to be present in their composition, since the action of a strong heat produces only the same volatile alkali common to all animal substances. They communicate all their activity to vinous spirits, without losing any of their form, and their native principles Neumann affirms to be a resinous, a gelatinous, and an earthy matter, whilst the principle in which their activity solely and wholly resides is the resin. This resinous extract is acrid and nauseous to the taste, and blisters the skin like the fly in substance, whilst the gelatinous matter freed from the resinous, is, like the earthy part, insipid and inactive. On distillation, this chemist obtained on an open fire, from three ounces of the insect, one ounce of urinous spirit, two drachms of empyreumatic oil, and two drachms ten grains of volatile salt. The caput mortuum weighed ten drachms, and when calcined, and elixated, scarcely afforded one grain of saline matter.

According to Lewis, this insect communicates nothing of it's fine green colour either to water or spirit of wine. It renders the first of a muddy, yellowish, or brownish colour, and is deprived considerably of it's beauty. The second it renders of a bright yellow, and itself becomes more beautiful and brighter than before. The active part is equally extracted by both menstrua, the gelatinous substance rendering the other soluble in water, the same as the gummy parts of vegetables do the resinous. Extracts made from them, according to this chemist, blistered equally alike, and as effectually as the cantharides in substance, but the two residua were equally inactive.

According to the experiments of Thouvenel, cantharides consist, 1st. Of a parenchyma, the nature and properties of which he has not determined, and which amounts to half the weight of the dried insect. 2d. Of one fourth



of a reddish bitter extractive matter, resembling that of ants, and which affords an acid on distillation. 3d. A small quantity, amounting to about twelve grains in the ounce, of a yellow, oily, or rather wax-like matter, which produces the golden yellow colour of the insect. 4th. Sixty grains of a green oily substance, analogous to wax, of a sharp taste, and in which the odour of this insect principally resides.

This substance, on distillation, gives a very penetrating acid, and a concrete oil, resembling wax. Water dissolves the extract, the yellow oil, and even a little of the green oil; but ether attacks only this last, and may be successfully employed to separate it from the others. The virtue of the cantharides seems to depend on this kind of green wax. Many experiments have convinced this chemist, that the extract so envelopes the oily part, as not to be entirely soluble in spirit of wine; hence to obtain this last at the same time with the extractive matter, so as to form in general a tincture well charged with these insects, it is necessary to use equal parts of alcohol and water mixed together. On distilling this mixed tincture, the alcohol that is extracted preserves a slight odour of the cantharides, and the different matters it held in solution separate from each other in proportion as the evaporation goes forward.

From bees and wasps this chemist obtained likewise a fat matter resembling wax, but the extract he found to differ from that of ants only in taste and colour. With respect to the May bugs, (*meloe proscarabeus* & *maialis*) according to Geoffroy, they contain much oil and volatile salt; and Thouvenel obtained from them a very stinking fluid, a colouring matter, an extract, and a fat substance that dissolved in alcohol and ether. This last he found to act particularly on the skin.

According to Accum, the yellow matter deposited in



vessels containing *spiders*, preserved in alcohol, is a true wax, and it may be obtained from these animals by gently heating them.

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## WOODLICE.

WE are informed by Neumann, that on distillation of these insects, watery liquors extract considerably more than spirituous. It had been commonly supposed that this insect contained a nitrous salt, from it's living in cellars, and other places impregnated with nitre ; and hence it was used in medicine in different diseases ; but this chemist was not able to extract any of this salt by analysis. A more exact examination of these insects has been made by Thouvenel, which presented him with peculiar properties. By distillation on the water bath, without addition, he found them to afford an insipid and alkaline phlegm, sometimes effervescing with acids, and changing violet sirup green ; in this operation, they lost five eighths of their weight. Treated afterward with water and alcohol, they afforded two drachms of soluble matter in the ounce, of which more than two thirds was extractive matter, and there remained an oily or waxy substance. These two products are easily separated by ether, which dissolves the last without touching the extract. These matters differ from those of ants and cantharides, by affording more carbonat of ammonia, and no acid in distillation, &c. It is observed by this chemist, that amongst insects, the woodlice appear to have the same relation to ants and cantharides, that oviparous quadrupeds and serpents have with respect to real or viviparous quadrupeds. The neutral salts contained in these insects are very small in quantity, and difficult to extract. He obtained, however, muriats of lime and of potash.

## WORMS.

Worms.

EARTH worms, or lumbrici, are the inhabitants more particularly of moist fat grounds, and are not fond of dry sands, in which they are rarely or never seen ; after rain, they rise to the surface to enjoy the moisture, when they fall a prey to different birds, and this is the best time of collecting them. Reaumur proposes their collection in order to feed domestic fowls instead of grain, computing that they exceed in quantity that of every kind of grain reaped by man. They were formerly used in medicine, but as they soon become putrid on account of their copious slimy juice, it is necessary for preservation immediately to dry them either before the fire or sun. We are informed by Neumann, that if these earth-worms be moistened with wine or vinous spirits, to prevent their putrefaction, and placed in a wide mouthed glass, in a cellar, they are in a few days almost wholly resolved into a slimy liquor. He found that on digestion of fresh worms in water or rectified spirit, the quantity of extract obtained from the first is not only greater in quantity than from the second, but the collective quantity extracted by both menstrua was greater when water, than when spirit was first applied. He found, that watery liquors extracted likewise more from woodlice, and considerably more than spirituous ones, although the quantity of matter, soluble in either, was not nearly so large in them as in the earth worm. When dried, and distilled in an open fire, they afforded him a volatile urinous spirit, concrete volatile salt, empyreumatic oil, and the remainder, after incineration and lixiviation, gave a fixed alkaline salt. If putrid before distillation, the product is almost merely a phlegm, or only a very little

oil, and volatile salt. According to Thouvenel, earthworms, as well as woodlice, constantly afforded him the muriats of lime and of potash, whilst in ants and cantharides these two bases, the first of which always appeared to him to be more abundant, are united to an acid, which has the character of the phosphoric. It is necessary however to observe, that this chemist has neither described the methods of extracting these salts, nor the processes he employed to ascertain their nature.

Neumann's Chemistry by Lewis.—Thouvenel Analyse des Insectes, Hist. de la Société de Médecine de Paris, p. 331. 1776.—Fourcroy's Elémens, tom. 4. 4th edit. Paris, 1791.

END OF VOL. II.



After a short rest at 10:30 AM, the weather was  
 still cloudy. The wind was from the west, and  
 the temperature was 65°. The water was calm, and  
 the fish were not very active. The birds were  
 very noisy, and the insects were very numerous.  
 The weather was very pleasant, and the view  
 was very beautiful. The water was very clear,  
 and the fish were very numerous. The birds  
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